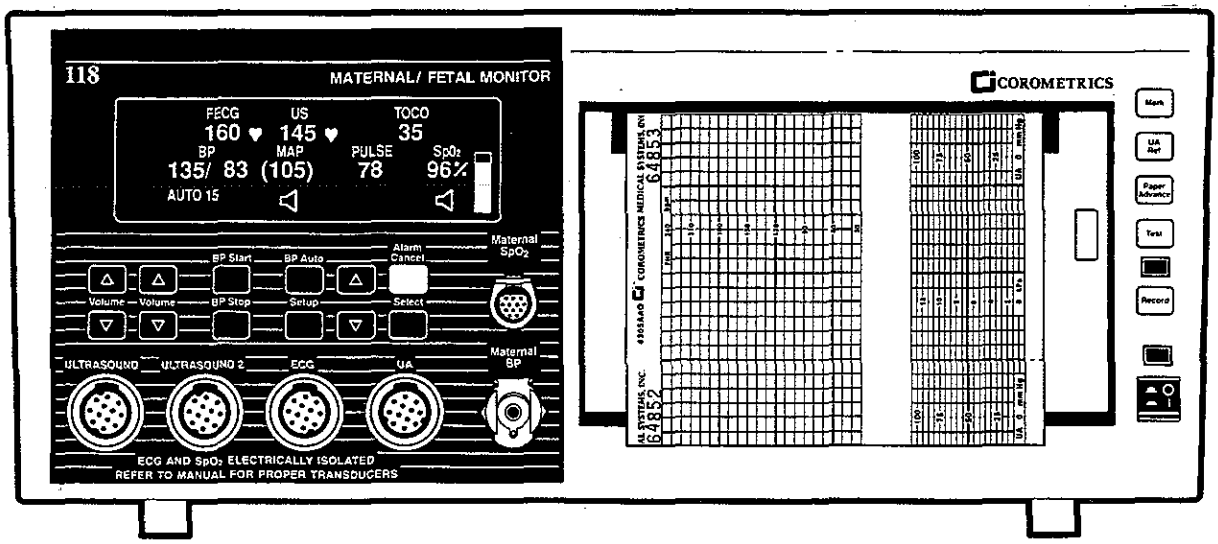
Model 118

MATERNAL / FETAL MONITOR

SERVICE MANUAL P/N 11267AA-01



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A Marquette Company

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COROMETRICS MEDICAL SYSTEMS, INC.
A Marquette Company
61 Barnes Park Road North
Wallingford, Connecticut U.S.A. 06492

FOR SERVICE CONTACT:

24-Hour Service Telephone Numbers
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PREFACE

ABOUT YOUR MONITOR

The Model 118 is an intrapartum maternal/fetal monitor. The Model 118 provides standard fetal monitoring parameters — dual ultrasound, fetal ECG, maternal ECG, and uterine activity — with optional integrated maternal pulse oximetry (SpO_2) and non-invasive blood pressure monitoring (BP).

This manual is written for the fully-equipped monitor — therefore some sections will not apply if your monitor is not equipped with maternal SpO_2 or maternal BP monitoring capabilities. If your monitor is not equipped with maternal SpO_2 monitoring capabilities, the **Maternal SpO_2** connector is not installed. If your monitor is not equipped with maternal BP monitoring capabilities, the **Maternal BP** connector is not installed and the **BP Start**, **BP Stop**, and **BP Auto** pushbuttons are not present on the front panel.

In summary, the Model 118 allows you to incorporate maternal capabilities as your clinical needs require and your budget allows. Contact your Sales Representative for more information regarding Model 118 upgrade information.

⚠ SAFETY INFORMATION

The **DANGERS, WARNINGS** and **CAUTIONS** that appear throughout this manual are not only preventative measures designed to uphold the safety of both patient and operator, but also enhance equipment reliability. The definitions of **DANGER, WARNING** and **CAUTION** in this manual comply with ANSI Z535.2, American National Standard for Environmental and Facility Safety Signs, and ANSI Z535.4, Product Safety Signs and Labels, issued by the American National Standards Institute.

⚠ **DANGER** indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ **WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ **CAUTION** indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.

⚠ **IMPORTANT** indicates an *emphasized* note. It is something you should be particularly aware of; something not readily apparent.

DEFINITION OF SYMBOLS

⚠ This symbol complies with IEC 601.1, and is described in IEC publication 348. The symbol prescribes the following information to the equipment user: **ATTENTION, CONSULT ACCOMPANYING DOCUMENTS.**

This symbol complies with IEC 601.1 and is described in IEC publication 878-02-02. The symbol prescribes the following information to the equipment user: **TYPE B EQUIPMENT.***

This symbol complies with IEC 601.1 and is described in IEC publication 878-02-03. The symbol prescribes the following information to the equipment user: **TYPE BF EQUIPMENT.***

~ This symbol complies with IEC 601.1 and is described in IEC publication 417-5032. The symbol prescribes the following information to the equipment user: **ALTERNATING CURRENT.**

This symbol complies with IEC 601.1 and is described in IEC publication 417-5016. The symbol prescribes the following information to the equipment user: **FUSE BOX.***

This symbol complies with IEC 601.1 and is described in IEC publication 417-5021. The symbol prescribes the following information to the equipment user: **EQUIPOTENTIALITY.**

O This symbol complies with IEC 601.1 and is described in IEC publication 417-5008. The symbol indicates the power is **OFF (power: disconnection from the mains).**

I This symbol complies with IEC 601.1 and is described in IEC publication 417-5007. The symbol indicates the power is **ON (power: connection to the mains).**

GENERAL USE

⚠ **DANGER:** This equipment is not designed for use in an explosive atmosphere, in the presence of flammable anesthetics, or inside an oxygen tent. Use under these conditions may present an explosion hazard.

Read this manual before operating the Model 118 Maternal/Fetal Monitor. Keep this manual available for future reference and for the orientation of new personnel.

Refer to the supplementary *Guide to Fetal Heart Rate Monitoring* for more information concerning the limitations of internal and external fetal heart rate monitoring techniques.

⚠ **WARNING:** This equipment is not designed for use with defibrillators or high-frequency surgical devices. This device is not intended for direct cardiac connection.

⚠ **WARNING:** Measurements may be affected in the presence of cardiac pacemakers or other electrical stimulators.

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* *This symbol is used on Model 118 Monitors manufactured for the United Kingdom. This symbol does not appear on units manufactured for the United States. For simplicity in the manual, all illustrations show the US symbols.*

⚠ **CAUTION:** Operation outside of the humidity range specified in this manual may result in degradation of the accuracy of the recorded data.

The equipment should be kept clean, dry, and free of transducer gel and other substances.

Do not operate the unit if any component is damp or wet due to condensation or spills. Avoid moving the equipment from a cold environment to a warm humid location. If the equipment is brought inside from outdoors, and is cold to the touch or below room temperature, allow the unit to stabilize at room temperature before operating.

Use only Corometrics approved patient cables, transducers, and sensors with the monitor. If a patient cable, power cord, or power plug is cracked, frayed, broken, or damaged in any way, it should be replaced immediately. Do not remove equipment covers. All repairs should be made by personnel authorized by Corometrics Medical Systems.

If the monitor fails to respond as described, do not use it until the unit has been serviced by qualified personnel.

Do not, under any circumstances, perform any testing or maintenance on the monitor while the unit is being used to monitor a patient.

This equipment contains components which may be destroyed or damaged by electrostatic discharge. Always use appropriate anti-static precautions when servicing this monitor. Such precautions include use of the following:

- grounded soldering irons
- anti-static solder removers
- grounded wrist straps
- grounded floor and bench mats
- conductive storage containers for PC boards and components

SAFETY PRECAUTIONS

Domestic (U.S.A.) equipment models are equipped with a hospital grade three-wire power plug and are designed to operate from a standard 120 VAC electrical outlet at 50–60 Hz . Equipment models manufactured for the United Kingdom are equipped with a standard UK fused three-wire power plug and are designed to operate from a standard 230 VAC electrical outlet at 50–60 Hz. Corometrics recommends the use of dedicated AC power lines. The equipment can be modified to operate from any of the following AC sources: 100, 120, 220, 230, or 240 volts at 50 or 60 Hz; however, only those personnel designated by Corometrics Medical Systems, Inc. are authorized to make such modifications.

⚠ **WARNING:** Do not defeat the three-wire grounding feature of the power cord by means of adaptors, plug modifications, or other methods. A dangerous shock hazard to both patient and operator may result.

⚠ **WARNING:** During defibrillation, all personnel must avoid contact with the patient and monitor to avoid a dangerous shock hazard.

LEAKAGE CURRENT

Corometrics' Model 118 Maternal/Fetal Monitor is designed to comply with Underwriters Laboratory (UL 544), CSA, IEC, and TUV standards for leakage current in patient-connected medical equipment. The system's inputs are electrically isolated as follows: the ECG input is Type BF; the ultrasound, blood pressure, and tocotransducers are Type B; and the SpO_2 input is Type BF. Leakage current is limited to a few microamperes even when full power line voltage is applied to these devices. However, for maximum patient safety, a leakage test should be conducted following any repair or servicing of the monitor. When conducting a leakage test, conform to the UL-544 standards or similar ones such as the AAMI Safe Current Limits Standard on Leakage Current. If the monitor is connected to other equipment, leakage current should be rechecked to ensure patient safety.

INTRODUCTION

MONITORING METHODS

The Corometrics Model 118 Maternal/Fetal Monitor is capable of monitoring two heart rates (maternal/fetal or twins), maternal uterine contractions, as well as maternal blood pressure and maternal pulse oximetry. Simultaneous trends of beat-to-beat heart rate and uterine activity (UA) are plotted continuously on the built-in strip chart recorder. (When enabled, the SpO_2 trend is also plotted on the uterine activity channel.). All fetal and maternal values are displayed on the front panel electro-luminescent (EL) display panel.

The Model 118 is capable of monitoring fetal and maternal parameters using the following clinical methods:

Fetal Heart Rate

The fetal heart rate can be measured using either external or internal methods:

External Method, Pulsed Doppler Ultrasound (US or US2): A transducer placed on the abdomen is used to direct an ultrasonic beam toward the fetal heart and to sense Doppler shifted echoes created by moving cardiac structures. Corometrics' autocorrelation process is used to determine the timing of successive cardiac cycles. The resulting fetal heart rate (FHR) pattern is recorded on the strip chart paper and the FHR appears on the EL display.

Internal Method, Direct Fetal ECG (FECG): FECG waveforms are obtained via a spiral electrode attached to the fetal presenting part. FHR is computed on a beat-to-beat basis using the R-to-R time interval on the QRS complex. The instantaneous FHR pattern is printed on the strip chart paper and the FHR appears on the EL display.

Maternal Uterine Activity

Maternal Uterine Activity can be measured through direct or indirect means:

External Method, Tocodynamometer (TOCO): Relative pressure within the uterus is measured using a tocotransducer attached to the abdomen in the area of the uterine fundus. The readings are recorded on the strip chart paper in a relative scale from 0 to 100 as well as illuminated on the EL display.

Internal Method, Corometrics Sensortip or Intrauterine Catheter and Strain Gauge (IUP): Intrauterine pressure is measured using a transcervical catheter. Pressure trends are plotted over the range of 0 to 100 mmHg (0 to 13.3 kPa) and the readings appear on the EL display.

Maternal Heart Rate / Pulse Rate

The maternal heart rate / pulse rate can be determined by three *external* monitoring methods as described below; however, only one value is *displayed* on the EL panel. If more than one method is employed, the order of display priority is ECG, pulse oximetry, and then blood pressure. Regardless of the pulse source for the *display*, the pulse rates determined by BP and SpO_2 are *printed* on the strip chart along with the respective blood pressure values and oxygen saturation value.

Maternal Electrodes (MECG): MECG signals are obtained via electrodes placed on the maternal chest and abdomen. The maternal heart rate (MHR) is computed on a beat-to-beat basis using the R-to-R time interval on the QRS complex. The instantaneous MHR pattern is printed on the strip chart recorder paper and the MHR appears on the EL display.

Maternal Pulse Oximetry (SpO_2): A transducer, applied to a maternal digit, senses a pulse of oxygenated arterial blood flow with each heartbeat. The resulting MHR appears on the EL display and is printed on the strip chart recorder at preset intervals and when a patient alarm occurs.

Maternal Blood Pressure (BP): A cuff, applied to a maternal limb, uses the oscillometric technique to sense pulses induced in the cuff at various pressure levels. The resulting MHR appears on the EL display and is printed on the strip chart recorder at the time of the reading.

Maternal Blood Pressure (BP)*

A cuff, applied to the maternal limb, uses the non-invasive oscillometric technique to determine the maternal systolic, diastolic, and mean arterial pressures. All determinations appear on the EL display and are printed on the strip chart recorder at every determination.

Maternal Pulse Oximetry (SpO_2)

A transducer, applied to a maternal digit, uses the principles of spectrophotometry and plethysmography to non-invasively measure the functional oxygen saturation of arterial hemoglobin. The resulting value is shown on the EL display and is printed on the strip chart recorder at preset intervals and whenever a patient alarm occurs. A bar graph indicator qualitatively indicates the pulse amplitude. The SpO_2 trend is *optionally* plotted on the strip chart paper.

* *Blood pressure is not automatically activated. It must be initialized via a front panel pushbutton. The mode, auto or manual, must also be selected via a front panel pushbutton.*

CONTROLS, INDICATORS, AND CONNECTORS

This section of the manual describes the controls, connectors, and displays of the Model 118.

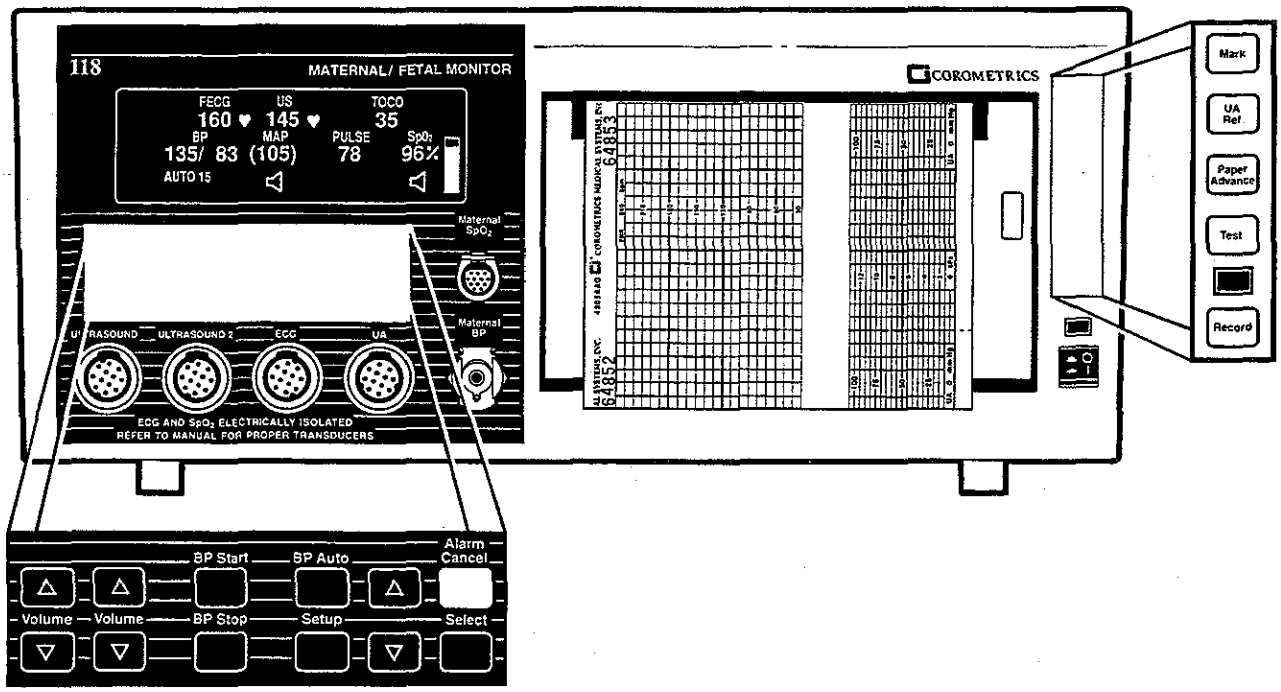


Figure 3-1. Model 118 Front Panel Controls

FRONT PANEL CONTROLS

The Model 118 front panel controls are shown in Figure 3-1. When reading this section, refer to Figure 3-1 for the location of each.

Power Pushbutton

The Model 118 power pushbutton, shown in Figure 3-1, is located on the lower right hand corner of the unit's front panel. Pressing the power pushbutton (I position) turns on the Model 118 and illuminates the green indicator lamp above the power pushbutton. Pressing the pushbutton again (O position), turns off the Model 118.

Mark Pushbutton

Pressing the Mark pushbutton, shown in Figure 3-1, causes a ↑ symbol to be printed on the heart rate channel of the strip chart paper.

Special feature when heart rate offset mode is enabled:

If the heart rate offset mode is enabled, pressing and holding this pushbutton for ***three seconds*** shifts the secondary heart rate trend +20 BPM.

UA Ref Pushbutton

The UA Reference pushbutton, shown in Figure 3-1, sets the pressure reference level on the UA recorder channel at 0 mmHg (0 kPa)* for intrauterine pressure monitoring or at relative 10 for the tocodynamometer. To set the UA reference, momentarily depress this pushbutton. The center margin of the strip chart is automatically annotated with UA REF.

If there is insufficient compensation range to provide 100 relative units or 100 mmHg (13.3 kPa) above the reference level, the UA display will flash **CHECK TOCO** or **CHECK IUP**.

Special features in external monitoring mode:

Pressing this button for more than two seconds causes the UA reference value and display to increment through the sequence 10, 15, 20, 25, 5, 10, 15, 20, 25,...etc., until the button is released. While the button is depressed, the strip chart tracing remains unchanged. When the button is released, the recorder trace and the UA display area take on this new value. This value is stored as the new reference level for the currently measured uterine activity signal.

Automatic baseline "re-referencing" occurs in the external UA monitoring mode. If pressure falls below 0, automatic UA reference occurs and new baseline reference is set at 0. The center margin of the strip chart is automatically annotated with UA REF.

Paper Advance Pushbutton

Pressing the Paper Advance pushbutton, shown in Figure 3-1, causes the recorder to advance chart paper for as long as the button is depressed. The speed gradually increases from 50 cm/min to 100 cm/min. Twenty seconds after the pushbutton is released, the recorder prints monitoring mode(s), time, date, and chart speed information (if the recorder is activated).

Test Pushbutton

Depression of the Test pushbutton, shown in Figure 3-1, initiates a monitor self-test routine. To activate, depress and hold for 1 second. To terminate the test, depress and hold for 1 second.

Record Pushbutton

Pressing the Record pushbutton, shown in Figure 3-1, activates the strip chart recorder, provided paper is installed. Once the recorder is activated, pressing the Record pushbutton again turns the recorder off.

The yellow indicator light located above the Record pushbutton illuminates when the recorder is activated. Turning the recorder off, or running out of recorder paper causes the yellow indicator light to turn off. When the recorder paper is approaching its end, the yellow indicator light will flash. When the recorder is out of paper, it will automatically stop and cannot be restarted until chart paper is installed.

Volume △ ▽ Pushbuttons

The four pushbuttons, shown in Figure 4-1, are used to control the volume of sound emitted by the rear panel speaker. The left pair of Volume △ ▽ pushbuttons raises and lowers the volume of the audio signals for the mode shown in the Heart Rate #1 Area.† The right pair of Volume △ ▽ pushbuttons raises and lowers the volume of the audio signals for the mode shown in the Heart Rate #2 Area.†

* *The Model 118 is factory-set to display pressure values in mmHg but can be changed to indicate kPa. Refer to Section 5, Setup Procedures, in this manual for more information.*

† *Refer to Figures 3-2a through 3-2d on pages 3-5 and 3-6.*

Pressing a Volume pushbutton with the △ symbol causes the volume to increase. Pressing the Volume pushbutton with the ▽ symbol causes the volume to decrease. Continuous depression of the Volume △ pushbutton results in full range audio volume. Volume settings have no effect on the processing used to determine heart rate.

Alarm Cancel Pushbutton

Depression of the Alarm Cancel pushbutton, shown in Figure 3-1, cancels the visual and audible indication of an individual alarm, with the exception of certain system alarms. The re-alarm time for MECG and SpO_2 is adjustable through the setup menus.

> **NOTE:** If an alert condition occurs while in Setup Mode, only an audible alarm indication is given. Depression of this pushbutton to cancel an alarm during Setup Mode will only "half-cancel" the alarm — it will remove the audio alarm. Upon exiting Setup Mode, the visual alarm indication will remain until the alarm is fully cancelled by depressing the Alarm Cancel pushbutton one more time.

Setup Pushbutton

The Setup pushbutton, shown in Figure 3-1, is used to enter and exit the setup menus that are provided to tailor the unit for varying clinical applications.

Depression of this pushbutton the first time displays the first setup screen which allows you to:

- select a time interval for automatic blood pressure determinations;
- set the SpO_2 pulse volume;
- choose the averaging mode for SpO_2 response time;
- define the strip chart printing interval for SpO_2 readings;
- enable/disable SpO_2 trend trace printing;
- set the time and date.

Depression of this pushbutton a second time displays the second setup screen which allows you to:

- enable/disable the BP, SpO_2, and MECG audio alarms;
- define the high and low alarm limits for systolic, diastolic, and mean arterial blood pressures, pulse rate, and oxygen saturation;
- set the audio alarm volume;
- set the re-alarm time for SpO_2 and MECG.

Depression of this pushbutton a third time returns the display to normal operation.

⚠ **IMPORTANT:** While in setup mode, the unit is monitoring both fetal and maternal parameters and under an alarm condition, an audio alarm will be issued (if enabled) — the setup mode does not provide a visual alarm indication. Depression of the Alarm Cancel pushbutton will remove the audio alarm.

Upon exiting setup mode, the visual alarm indication is shown, regardless of whether or not the audio alarm is enabled and regardless of whether or not the Alarm Cancel pushbutton was depressed while in setup mode.

△ ▽ Pushbuttons

The set of △ ▽ pushbuttons, shown in Figure 3-1, is primarily used within the setup menus but is also used to adjust the SpO_2 pulse volume.

While in setup mode, the buttons are used to cycle through available choices for a menu field. Depression of the △ button causes the selected field to increment through the available values or modes of operation. Depression of the ▽ button causes the selected field to decrement through the available values or modes of operation.

Special feature while monitoring SpO_2:

Under normal operation **and** with active pulse oximetry, these pushbuttons provide a shortcut for adjusting the SpO_2 "beep" volume. Pressing the △ pushbutton causes the SpO_2 volume to increase. Pressing the ▽ pushbutton causes the SpO_2 volume to decrease. If pulse oximetry is not in use, depressing these pushbuttons has no effect. (SpO_2 volume can also be adjusted through the setup menus.)

BP Start Pushbutton

The BP Start pushbutton, shown in Figure 3-1, is a multi-function pushbutton. Momentary depression of this pushbutton: begins a blood pressure determination in manual mode; or starts the first determination in automatic mode; or begins a determination in-between automatic determinations.

Functionality in Manual Mode: When the monitor is configured for manual mode, depression of this pushbutton begins a single determination.

Functionality in Auto Mode: When the automatic mode is first selected, **you must then depress this pushbutton to initiate the sequence of determinations.** Depression of this button during the interval between determinations begins an additional determination but does not reset the countdown timer. Timed determinations will continue as normal.

BP Stop Pushbutton

Depression of the BP Stop pushbutton, shown in Figure 3-1, cancels a blood pressure determination in progress and deflates the cuff. The active blood pressure mode (auto or manual) remains selected.

Special Feature in Manual Mode:

If a determination is ***not*** in progress, depression of this pushbutton removes the numerics of the previous reading from the display. However, there must be a three second delay since the button was last depressed. (For example: if you depress this pushbutton to cancel a determination in progress; you must then pause for three seconds prior to depressing it a second time to remove the previous reading from the display.)

BP Auto Pushbutton

The BP Auto pushbutton, shown in Figure 3-1, is a momentary pushbutton which controls the blood pressure monitoring mode; depression of this button selects between the manual and automatic modes of operation. Manual mode is entered when power is first applied to the monitor. When Manual mode is selected, the **BP Start** pushbutton makes a single determination. When Auto mode is first selected, the word **AUTO** is displayed, along with the interval time setting; depression of the **BP Start** pushbutton initiates the first determination. **You must depress the BP Start pushbutton to initiate the sequence of determinations.**

Special Feature:

Pressing and holding this pushbutton for more than three seconds causes the display to increment through the interval times for automatic blood pressure readings until the button is released. During adjustment, the interval time replaces the countdown. The choices are 1*, 2, 3, 4, 5, 10, 15, 30, 60, and 120 minutes. (Note this feature is only available during normal operation—it does not function while in setup mode.)

Select Pushbutton

The Select pushbutton, shown in Figure 3-1, is active only from the setup menus. Successive depression of this button causes a cursor ▶ to move from field to field in the setup menus. The cursor points to the active field.

* *The Model 118 is factory-set with the optional 1-minute interval time disabled. For information on enabling the 1-minute interval, refer to Section 5, Setup Procedures, in this manual.*

FRONT PANEL DISPLAYS AND INDICATORS

When a Model 118 is equipped with all optional maternal parameters, the electroluminescent (EL) display is divided into two lines. The top line shows the Heart Rate #1, the Heart Rate #2, and the Uterine Activity information. The bottom line shows the Maternal Blood Pressure (BP), Maternal Heart Rate (MECG) or Pulse Rate (PULSE), and Maternal Oxygen Saturation (SpO_2) information.

The content and layout of the display panel can change, depending on which parameters are being measured and the modes of operation in use.

Figure 3-2a: If BP and/or SpO_2 are in use, the fetal parameters appear on the top line while the maternal parameters are displayed on the bottom line.

Figure 3-2b. If SpO2 is inactive, that portion of the display is unused.

Figure 3-2c: If BP and/or SpO_2 are in use, as well as MECG, the maternal rate is then derived from the MECG electrodes and displayed on the bottom line.

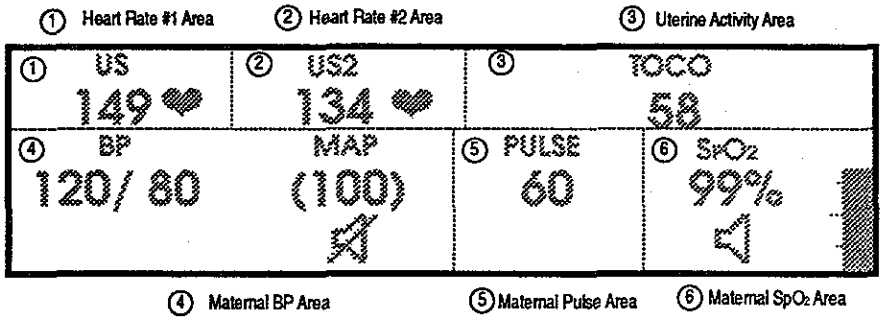


Figure 3-2a. Model 118 Display — Optional Maternal Parameters Active (BP and SpO2)

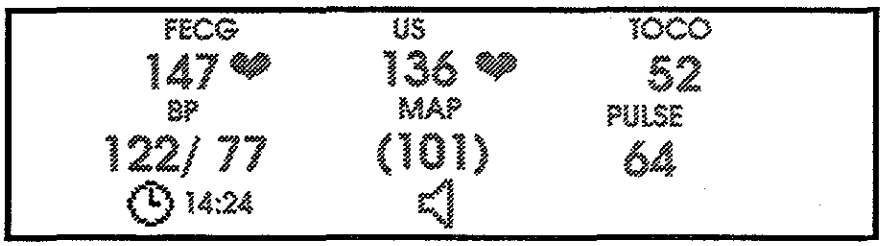


Figure 3-2b. Model 118 Display — BP Optional Maternal Parameters Active (SpO_2 Inactive)

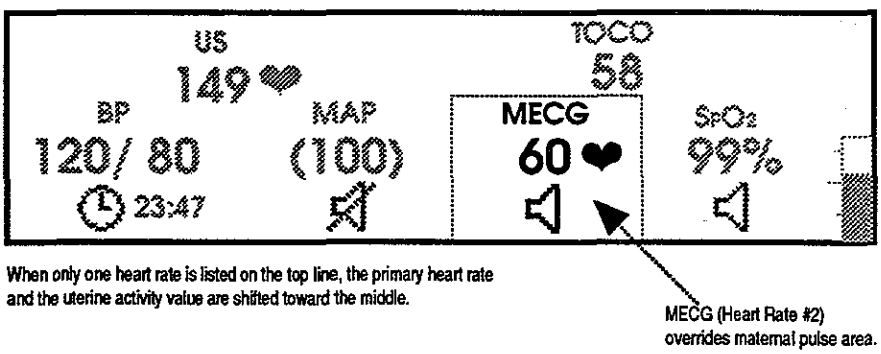
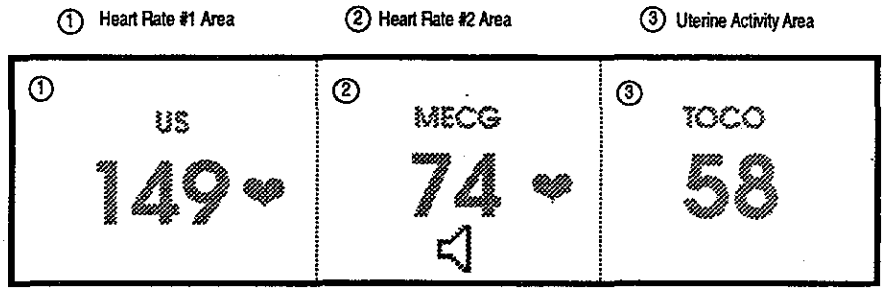


Figure 3-2c. Model 118 Display — MECG and Optional Maternal Parameters Active

Figure 3-2d: If BP and SpO_2 are not in use, the fetal parameters (and MECG, if active) are enlarged and centered in the display.

Figure 3-2e: If no transducers are plugged into the monitor the Corometrics logo screen is displayed.

Figure 3-2f. If no activity is sensed for fifteen minutes a screen saver feature is activated. The screen saver is indicated by a blank screen with a small Corometrics logo that floats on the screen.



When BP and SpO_2 are NOT being used, the standard parameters are enlarged to fill the screen for easier viewing.

Figure 3-2d. Model 118 Display — Optional Maternal Parameters Inactive

Figure 3-2e. Model 118 Display — No Transducers Plugged into Monitor

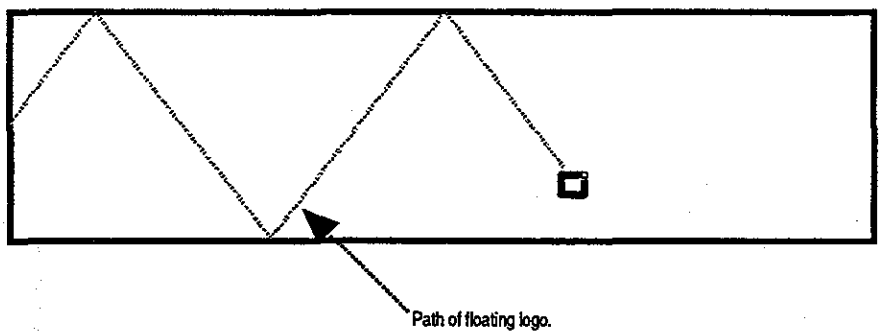


Figure 3-2f. Model 118 Display — Screen Saver Active

Heart Rate #1 Area

The Heart Rate #1 Area, shown in Figures 3-2a, 3-2b, 3-2c, and 3-2d, is comprised of three items: the alphanumeric mode legend, the numeric heart rate value, and the heartbeat indicator.

Heart Rate #1 Mode. The mode is an alphanumeric legend indicating the monitoring mode in use. The mode corresponds to:

- **FECG** (FECG alone; or FECG and US; or FECG and US2); or
- **US** (US alone; or US2 alone; or US and US2; or US and MECG; or US2 and MECG)

NOTE: When only one ultrasound connector is used to obtain the fetal heart rate, the mode will display **US** regardless of whether the US or US2 connector is being used. The mode **US2** is only displayed in the Heart Rate #2 position and only when dual heart rate monitoring is in progress using both ultrasound connectors.

Heart Rate #1 Value. Three digits indicating fetal heart rate in beats per minute.

Heartbeat Indicator ♥ . The flashing heart ♥ symbol is located on the right side of the Heart Rate #1 Value. The indicator flashes with each detected valid heartbeat for Heart Rate #1.

Heart Rate #2 Area

The Heart Rate #2 Area, shown in Figures 3-2a, 3-2b, 3-2c, and 3-2d, is comprised of three items: the alphanumeric mode legend, the numeric heart rate value, and the heartbeat indicator. (For MECG only, a fourth item, the MECG Heart Rate Alarm Enable/ Disable Indicator, is displayed in the Heart Rate #2 Area.)

Heart Rate #2 Mode. The mode is an alphanumeric legend indicating the monitoring mode in use. The mode corresponds to:

- **US** (FECG and US; or FECG and US2); or
- **US2** (US and US2); or
- **MECG** (MECG alone; or MECG and US; or MECG and US2)

NOTE: MECG information is displayed in the Heart Rate #2 Area if BP ***and*** SpO_2 are ***not*** being used to monitor maternal parameters. Otherwise, MECG information is displayed in the Maternal Heart Rate / Pulse Area.

Heart Rate #2 Value. Three digits indicating fetal heart rate in beats per minute.

Heartbeat Indicator ♥ . The flashing heart ♥ symbol is located on the right side of the Heart Rate #2 Value. The indicator flashes with each detected valid heartbeat for Heart Rate #2.

MECG Heart Rate Alarm Enable/Disable Indicator. This symbol applies to MECG and provides information about the audio alarm ***and*** the high/low alarm limit settings.

The Alarm Disable Indicator is provided as a warning that at least one of the following conditions exists:

- The MECG Audio Alarm is off.
- The Pulse (Heart Rate) High Limit is off.
- The Pulse (Heart Rate) Low Limit is off.

The Alarm Enable Indicator is displayed to give you confidence that the MECG Audio Alarm is on ***and*** each of the Pulse (Heart Rate) Limits is set to a value. However, it is recommended that prior to monitoring each patient, you check the alarm limit settings to ensure they are appropriate for the patient.

NOTE: MECG information is displayed in the Heart Rate #2 Area if BP ***and*** SpO_2 are ***not*** being used to monitor maternal parameters. Otherwise, MECG information is displayed in the Maternal Heart Rate / Pulse Area, including the Heartbeat Indicator and MECG Alarm Enable/Disable Indicator.

Uterine Activity Area

The Uterine Activity Area, shown in Figures 3-2a, 3-2b, 3-2c, and 3-2d, is comprised of two items: the alphanumeric mode legend and the numeric uterine activity value.

Uterine Activity Mode. The mode is an alphanumeric legend indicating the monitoring mode in use. The mode corresponds to **TOCO** or **IUP**.

Uterine Activity Value. Three digits* indicating uterine activity values. The values represent mmHg (kPa) for internal uterine activity monitoring and relative units for tocotransducer external monitoring.

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* *If pressure values are displayed in kPa, each value includes a decimal point. Values displayed in mmHg will not include a decimal point. For example: 13.3 kPa or 100 mmHg.*

BP Area

The Maternal BP Area, shown in Figure 3-2a, is comprised of up to seven items: two alphanumeric legends, three numeric pressure values, the monitoring mode, and the BP alarm enable/disable indicator.

Blood Pressure Legends. When a BP reading is successful, the legend **BP** indicates systolic/diastolic pressure and the legend **MAP** indicates the mean arterial pressure. During a determination, the instantaneous cuff pressure is displayed in place of the mean arterial pressure and is indicated by the word **CUFF.**

Blood Pressure Values. The systolic and diastolic pressures are each indicated with three digits* and are separated by a slash (/). The mean arterial pressure (MAP) is indicated by three digits* enclosed in parentheses. During a determination, the instantaneous cuff pressure is displayed in place of the mean arterial pressure and is indicated by the word **CUFF.** The unit is factory-set to display pressure values in mmHg but can be changed by qualified personnel to indicate kPa. Refer to *Section 5, Setup Procedures* for more information.

Blood Pressure Mode. Display area indicating the active state of the blood pressure module. In manual mode, this display area is blank as shown in Figure 3-2a. In auto mode, prior to the initialization of the first reading, the word **AUTO** is displayed along with the current interval time setting in minutes. In auto mode, once the automatic readings have been initiated, a small clock symbol will appear along with a countdown timer (mmm:ss) indicating the time until the next reading. The time is listed in minutes and seconds as shown in Figure 3-2b.

BP Alarm Enable/Disable Indicator. This symbol applies to BP and provides information about the audio alarm ***and*** the high/low alarm limit settings.

The Alarm Disable Indicator is displayed as a warning that at least one of the following conditions exists:

- The BP Audio Alarm is off.
- One or more of the Blood Pressure High Limits (Systolic, Diastolic, Mean) are off.
- One or more of the Blood Pressure Low Limits (Systolic, Diastolic, Mean) are off.
- The Pulse High Limit is off. (Only affects indicator if BP is the pulse source — MECG and SpO_2 are inactive.)
- The Pulse Low Limit is off. (Only affects indicator if BP is the pulse source — MECG and SpO_2 inactive.)

The Alarm Enable Indicator is displayed to give you confidence that the BP Audio Alarm is on ***and*** each of the High/Low Alarm Limits is set to a value. However, it is recommended that prior to monitoring each patient, you check the alarm limit settings to ensure they are appropriate for the patient.

Maternal Heart Rate / Pulse Area

The Maternal Heart Rate / Pulse Area, shown in Figures 3-2a, 3-2b, and 3-2c, contains either two or four items. If MECG is ***not*** in use, the maternal pulse area will contain two items: an alphanumeric legend and a numeric value. If MECG monitoring is in use, the display area will also contain an MECG heart rate alarm enable/disable indicator and heartbeat indicator. (In this case, MECG information is ***not*** displayed in the Heart Rate #2 Area.)

Maternal Heart Rate / Pulse Legends. Legend indicating that the maternal rate is being monitored. If the rate is determined from either of the SpO_2 or BP modules, the legend displays **PULSE.** If the pulse is determined by the MECG portion of the fetal monitor, the legend displays **MECG.**

Maternal Heart Rate / Pulse Value. Three-digit display indicating the maternal rate in beats per minute. The maternal rate is determined by the following priority: MECG from the monitor's ECG section; pulse derived from the SpO_2 module; or pulse derived from the BP module.

Maternal Heartbeat Indicator ♥ . This symbol is present only when the MECG method of monitoring is in use. The ♥ symbol is located on the right side of the maternal heart rate value. The indicator flashes with each detected valid heartbeat.

MECG Heart Rate Alarm Enable/Disable Indicator. This symbol applies to MECG and provides information about the audio alarm ***and*** the high/low alarm limit settings.

The Alarm Disable Indicator is provided as a warning that at least one of the following conditions exists:

* *If pressure values are displayed in kPa, each value includes a decimal point. Values displayed in mmHg will not include a decimal point. For example: 13.3 kPa or 100 mmHg.*

- The MECG Audio Alarm is off.
- The Pulse (Heart Rate) High Limit is off.
- The Pulse (Heart Rate) Low Limit is off.

The Alarm Enable Indicator is displayed to give you confidence that the MECG Audio Alarm is on ***and*** each of the Pulse (Heart Rate) Limits is set to a value. However, it is recommended that prior to monitoring each patient, you check the alarm limit settings to ensure they are appropriate for the patient.

> **NOTE:** MECG information is displayed in the Heart Rate #2 Area if BP ***and*** SpO_2 are ***not*** being used to monitor maternal parameters. Otherwise, MECG information is displayed in the Maternal Heart Rate / Pulse Area, including the Heartbeat Indicator and MECG Heart Rate Alarm Enable/ Disable Indicator.

Maternal SpO_2 Area

The Maternal SpO_2 Area, shown in Figure 3-2a, is comprised of four items: alphanumeric legend, numeric value, SpO_2 alarm enable/disable indicator, and pulse amplitude indicators.

Oximetry Legend. The **SpO_2** legend indicates that oxygen saturation monitoring is in progress.

Oximetry Value. Three-digit display indicating the percentage of oxygen in the mother's blood.

SpO_2 Alarm Enable/Disable Indicator. This symbol applies to SpO_2 and provides information about the audio alarm ***and*** the high/low alarm limit settings.

The Alarm Disable Indicator is displayed as a warning that at least one of the following conditions exists:

- The SpO_2 Audio Alarm is off.
- The SpO_2 % Low Limit is off.
- The Pulse High Limit is off. (Only affects indicator if SpO_2 is the pulse source — MECG inactive.)
- The Pulse Low Limit is off. (Only affects indicator if SPO_2 is the pulse source — MECG inactive.)

The Alarm Enable Indicator is displayed to give you confidence that the SpO_2 Audio Alarm is on ***and*** each of the High/Low Alarm Limits is set to a value. However, it is recommended that prior to monitoring each patient, you check the alarm limit settings to ensure they are appropriate for the patient.

Pulse Amplitude Indicator. Vertical bar indicator that qualitatively indicates pulse amplitude.

FRONT PANEL CONNECTORS

The Model 118 front panel connectors are shown in Figure 3-3. When reading this section, refer to Figure 3-3 for the location of each connector.

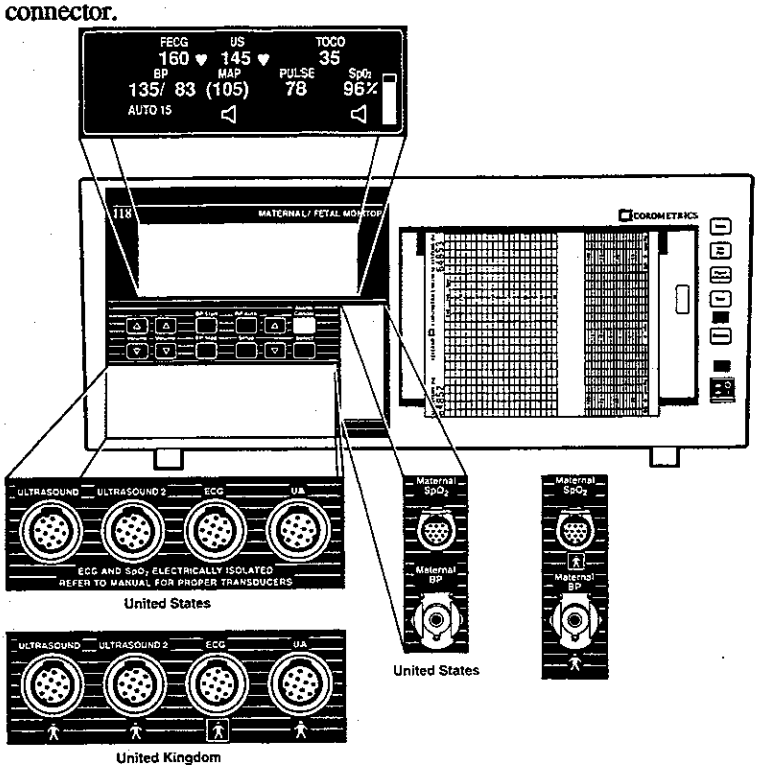

Figure 3-3. Model 118 Front Panel Connectors

US Connector

The US connector, shown in Figure 3-3, is a light-gray, 12-pin connector electrically keyed to recognize when an ultrasound transducer is inserted. The connector is also mechanically keyed to accept only a Corometrics 9-crystal ultrasound transducer.

US2 Connector

The US2 connector, shown in Figure 3-3, is a second light-gray, 12-pin connector identical to the US connector described above.

ECG Connector

The ECG connector, shown in Figure 3-3, is a dark-gray, 12-pin connector mechanically keyed to accept only the Corometrics MECG cable or FECG cable/ legplate plug. The connector is electrically keyed to recognize which plug is inserted.

UA Connector

The UA connector, shown in Figure 3-3 is a white, 12-pin connector mechanically keyed to accept only the Corometrics tocotransducer, the Corometrics Sensortip interconnect cable, or the strain gauge plugs. The connector is electrically keyed to recognize which plug is inserted.

Maternal SpO_2 Connector

The Maternal SpO_2 connector, shown in Figure 3-3, is a gray connector mechanically keyed to accept Corometrics Intermediate Cable for use with Nellcor D-25 or D-25L SpO_2 Sensors.

Maternal BP Connector

The Maternal BP connector, shown in Figure 3-3, is used to attach the Corometrics pneumatic hose and single-tube BP cuff assembly.

STRIP CHART RECORDER

The dual channel strip chart recorder, shown in Figure 3-4, is located on the right side of the front panel. The lever on the right side of the recorder opens the paper drawer.

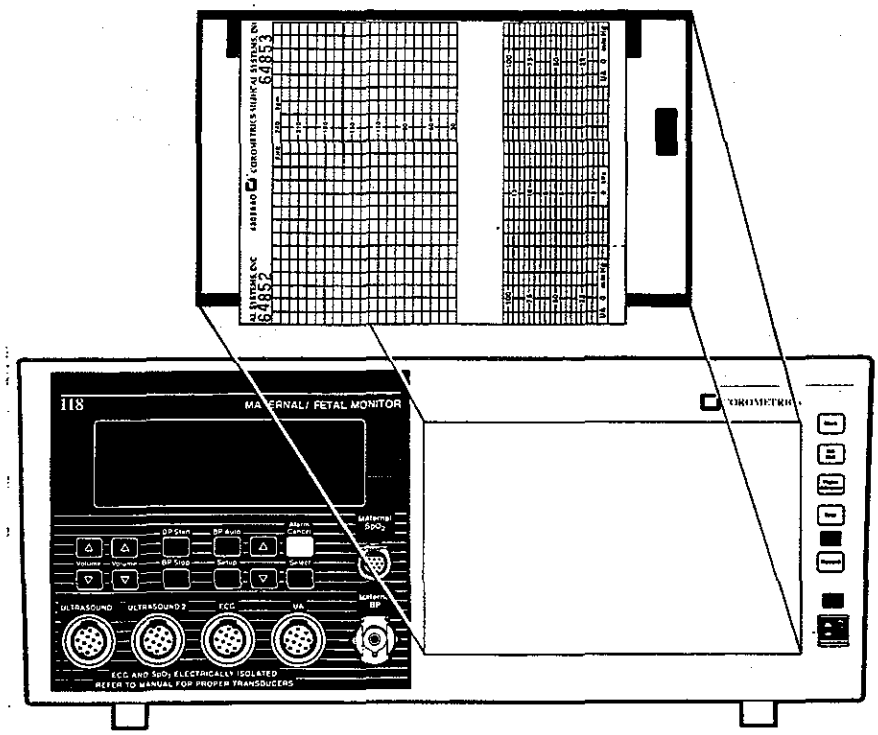

Figure 3-4. Model 118 Strip Chart Recorder.

Heart Rate Channel

The strip chart recorder is capable of printing two heart rate trends simultaneously on the left side of the recorder paper. One heart rate is printed in normal print density while the other is printed in a heavier density.

Uterine Activity / SpO_2 Channel

The uterine activity channel prints on the right side of the strip chart recorder paper. The uterine activity printout on the recorder paper is scaled from 0 to 100 relative units for a tocotransducer or 0 to 100 mmHg for an intrauterine catheter. (When enabled, the SpO_2 trend is also plotted on the uterine activity channel, over a range of 60–100 % on Domestic Paper (HR Scale: 30–240 BPM) or 50–100 % on International Paper (HR Scale: 50–210 BPM). The uterine activity trend is printed in normal print density, while the SpO_2 trend is printed in a heavier density.)

Alphanumeric Printout

When the recorder is activated, time, date, monitoring mode(s), and paper speed are automatically printed between the heart rate and uterine activity channels on the strip chart recorder paper. Various messages relating to functions and parameter changes will be printed as they occur. SpO_2 values are printed at preset intervals, determined by menu selection, and when an SpO_2 patient alarm occurs. BP readings are printed at the conclusion of each determination. Maternal SpO_2 and BP values are accompanied by a diamond marker symbol to mark the time of the reading. Readings provided by the Model 118's internal modules are denoted by an open diamond marker ◊. Readings provided by an external SpO_2 or NIBP monitor are denoted by a solid diamond marker ♦. In addition, if the optional 2115 Keypad or 2116 Keyboard is used, messages keyed in by the operator appear in this margin.

REAR PANEL CONNECTORS

The Model 118 rear panel controls are illustrated in Figure 3-5. When reading this section, refer to Figure 3-5 for the location of each.

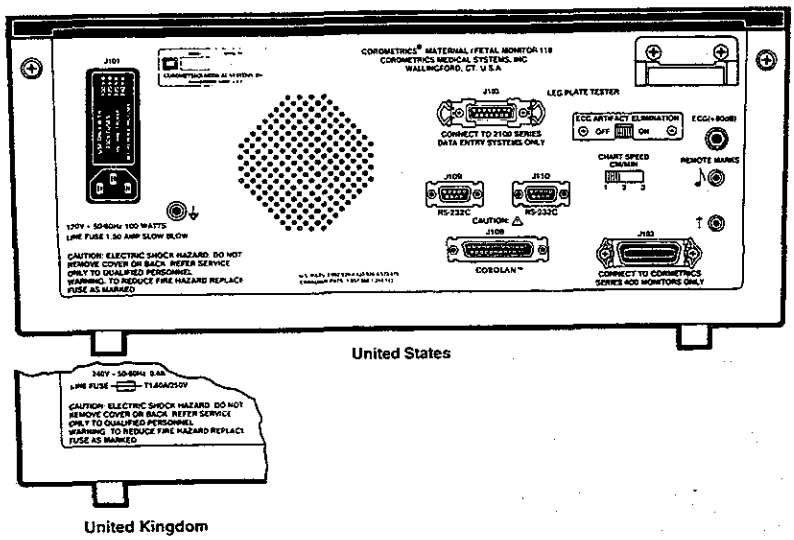

Figure 3-5. Model 118 Rear Panel Connectors

J101 Connector ~ ⊟

This is the receptacle for the AC line power cord. Integrated with this receptacle are the main unit fuse and the voltage selection card. Units manufactured for the United States are marked with the following power requirements: 120 V ~ 50–60 Hz and 100 W LINE FUSE 1.5 A SLOW BLOW. Units manufactured for the United Kingdom are marked with the following power requirements: 230 V ~ 50–60 Hz 0.4 A and LINE FUSE ⊟ T 1.6 A / 250 V. (Refer to the rear panel markings on your unit to verify line voltage, line frequency, and replacement fuse values.)

Equipotential Lug ⏚

Binding post terminal directly connected to chassis for use as an equipotentiality connection.

J103 Connector

The J103 connector, shown in Figure 3-5, is a 15-pin connector for connecting an optional Corometrics 2115 Keypad or 2116 Data Entry/Clinical Notes Keyboard. The Models 2115 and 2116 are each supplied with the appropriate interconnect cable for connection to J103.

Communication Connectors (J108, J109, J110)

The Model 118 communications package can be quickly identified by the presence of the rear panel connectors labeled J108, J109, and J110. These connectors, shown in Figure 3-5, are for the following:

J108: The J108 communication connector is a 25-pin D-shell connector labeled COROLAN. COROLAN is a Corometrics proprietary local area network signal standard which connects fetal monitors to a Corometrics MONARCH 8000 Obstetrical Management and Archival System or a Quantitative Medicine Quantitative Sentinel System.

J109: The J109 communication connector is a 9-pin D-shell connector labeled RS-232C. J109 is a programmable serial communication port designed for use with a variety of peripheral equipment. The Model 118 is supplied from the factory with J109 programmed for use with a Critikon DINAMAP non-invasive blood pressure monitor (Models 1846SX or 8100T). For use with other equipment, refer to *Section 13, External Device Interfacing*.

J110: The J110 communication connector is a 9-pin D-shell connector labeled RS-232C. J110 is a programmable serial communication port designed for use with a variety of peripheral equipment. The Model 118 is supplied from the factory with J110 programmed for use with a Corometrics Model 555 non-invasive blood pressure monitor. For use with other equipment, refer to *Section 13, External Device Interfacing*.

⚠ **CAUTION:** The maximum non-destructive voltage that may be applied to the rear panel connectors is 0 volts. Do not attempt to connect cables to these connectors without contacting your Biomedical Engineering Department or Corometrics Service. This is to insure the connectors comply with leakage-current requirements of one of the following applicable standards; Underwriters Laboratories U.L. 544, Canadian Standards Association CSA 22.2 No. 125, or International Electrotechnical Commission IEC 601-1.

Legplate Tester

The Legplate Tester, shown in Figure 3-5, uses an internal ECG simulator circuit for testing Corometrics Qwik Connect Spiral or 2-wire FECG cable/legplate assemblies. Refer to *Section 11, Transducer Servicing*, for more information.

ECG Artifact Elimination Switch

This switch affects only the direct FECG mode. The ECG Artifact Elimination switch, shown in Figure 3-5, is a two position slide switch which is locked in place by a retaining plate and two screws. The switch is factory set in the OFF position. Setting the switch to the ON position requires removing the plate, setting the switch to the ON position, and reversing the plate to lock the switch in the new position.

In the ON position, any new heart rate value which differs by more than ±25 BPM from the previously calculated heart rate is not printed.

In the OFF position, all heart rate values are printed without regard to previous rates.

Chart Speed Switch

The Chart Speed switch, shown in Figure 3-5, allows setting the paper advance rate on the strip chart recorder to either 1, 2, or 3 cm/min.

J102 Connector

The J102 connector, shown in Figure 3-5, allows connecting a Corometrics Spectra 400 Central Surveillance and Alert System or other central station system to the Model 118.

ECG (+80dB) Connector

The ECG (+80 dB) connector, shown in Figure 3-5, permits recording of Direct FECG or MECG signals on an external recorder. Output level is 10 V/mV, compatible with common adult ECG recorders.

Remote Marks Connector ♪

This connector is reserved for future use.

Remote Marks Connector ↑

The Remote Marks Connector ↑, shown in Figure 3-5, is provided for connection of an optional Corometrics Remote Event Marker. When connected to the Remote Marks Connector ↑, actuating the Remote Event Marker causes a ↑ symbol to be printed on the strip chart recorder paper.

Speaker

The Model 118 rear panel speaker is mounted behind the speaker grill shown in Figure 3-5. The speaker emits an audible tone for heart rate #1, heart rate #2, SpO_2 pulse with 0 %-dependent pitch, and for user notification and alarm conditions.

THEORY OF OPERATION

This section of the manual contains the electronic theory for the Model 118 Maternal/Fetal Monitor. The electronic theory is presented in two parts. First, a major function overview is given for each printed circuit (PC) board. Then, each board's individual circuits are discussed in detail. When possible, references will be made to the appropriate schematic contained in Section 13 of this manual.

PRINTED CIRCUIT BOARDS

The following gives the name and reference number of each Model 118 PC board, its location within the unit, and a brief description of it's major functions. The reference number is provided for locating parts lists, assembly drawings and schematics in Sections 14 and 15 of this manual. Refer to the Model 118 Final Assembly Drawing (No. 10770) and Model 118 Front Bezel Assembly Drawing (No. 10758) in *Section 15, Assembly Drawings and Parts Lists* for the location of boards withing the unit.

Power Supply Board (No. 8370)

The Power Supply Board is located on the right side of the Model 118 when viewing the unit from the front. The Power Supply Board is the main source for regulated dc voltages in the Model 118. The Power Supply Board is comprised of a multiple output dc-to-dc switching power supply, a linear dc-to-dc converter, a printer motor drive circuit and an adjustable dc output specifically for the strip chart recorder printhead. All circuits are individually fuse protected for safety and certain catastrophic failure conditions.

⚠ **WARNING:** The Power Supply Board fuses are not normal service devices. An open Power Supply Board fuse is an indication of a failure elsewhere in the circuit.

Display Board

The Model 118 front panel display is an electroluminescent (EL) glass panel with a mounted circuit board on the back, referred to as the Display Board. As its name implies, the Display Board provides the Model 118 front panel visual indicators for displaying all monitoring modes as well as the values for fetal heart rate, maternal heart rate, maternal blood pressure, maternal pulse oximetry, and maternal uterine activity. (The Display Board is manufactured by Planar Systems, Inc.)

The four basic operational signals needed to control the EL panel are handled by the Display Board after being processed on the Peripheral Board. Operating voltages are supplied by the Display Power Supply Board.

The Display Board and the Display Power Supply Board are calibrated in unison at the Planar factory. Due to calibration voltage adjustments, if replacement of either board is necessary, they must be replaced together as a matched pair.

Display Power Supply Board

The Display Power Supply Board is a dc-to-dc converter, mounted in the card cage. It converts the 12 Vdc and 5 Vdc input signals to high voltage (>200 Vdc) for use by the Display Board. (The Display Power Supply Board is manufactured by Planar Systems, Inc.)

Ultrasound Board (No. 9613)

The Ultrasound Board is comprised of two channels; Channel 1 and Channel 2. Each ultrasound channel generates a 1.151 MHz center frequency pulsed Doppler signal. The ultrasonic sound waves emitted from the transducer crystals enter the maternal abdomen and create echoes when they encounter an interface between tissues of differing acoustic impedance. If the interface is moving either toward or away from the ultrasound transducer, the frequency of the reflected sound differs from the frequency sent from the transducer. Each ultrasound channel also receives, amplifies, and detects the return signal. The audio signal is then sent to the Peripheral Board for routing to the speaker. The processed audio envelope is sent to the DSP Board for correlation. Each channel is the mirror image of the other. The single channel pulse repetition frequency is 4 KHz, while the dual channel pulse repetition frequency is 2 KHz per channel.

Multifunction Board (No. 7931)

The Multifunction Board contains the isolated preamplifier and ECG processing circuitry by which heartbeat event pulses are provided to the DSP Board

for heart rate calculation. The UA circuitry (tocotransducer and strain gauge) contains an instrumentation amplifier and low-pass filter which provides the DSP Board with a voltage output proportional to the input signal. The board also controls mode line buffering, the leg plate tester circuitry, telemetry/simulator output buffer, and audio output amplifier. The audio amplifier drives the rear-panel speaker with US audio tones, 1 KHz beeps for ECG mode heartbeats, and other audible tones (alarm tones, SpO_2 beeps, power-on tones, etc.).

Peripheral Board (No. 10621)

The Peripheral Board contains most of the I/O interface for the monitor. Included on this board are the front and rear panel control input, recorder controls, keyboard interface, heart rate and UA output signals, audio volume control circuitry, display circuitry, RS-232C control circuits, COROLAN circuitry, and NIBP/SpO_2 module communication circuitry.

CPU Board (No. 10622)

The CPU Board contains the main processor (68000, 16-bit, 16 MHz CMOS), which controls all I/O operations. The CPU Board takes heart rate, pressure and mode information located in shared memory on the DSP Board for transfer to the front panel display, recorder, etc. via the circuitry on the Peripheral Board. Included on the CPU Board are non-volatile RAM clock circuit, built-in battery (long-lasting Lithium), system interrupt controller, and reset circuitry. The communications circuitry includes a DMA controller as well.

DSP Board (No. 7937)

The DSP Board is the main signal processing board for the monitor and is the interface to the main CPU. It processes and correlates the US envelope, processes and peak detects the ECG signals and provides heart rates from these signals. The DSP Board also processes TOCO or strain gauge information and checks system mode information. Included on this board are the analog signal input multiplexer and A/D circuitry, transducer enable inputs, shared memory, and shared memory control circuitry.

SpO_2 Internal Module

This internal module is manufactured by Nellcor, Inc. The module handles all circuitry involving SpO_2 with the exception of the display circuitry. The module measures the maternal oxygen saturation and pulse rate using the principles of spectrophotometry and plethysmography. The SpO_2 sensor is comprised of two light-emitting diodes (LEDs), which are the emitters, and one photodiode which is the detector. One LED emits red light and the other infrared into the patient's skin. The detector receives the amount of light that is not absorbed at the sensor site and the module uses the relative absorption of red and infrared to compute the percentage of functional hemoglobin that is saturated with oxygen.

SpO_2 Interface Board (No. 10734)

This board provides patient isolation circuitry between the power supply and patient connections.

NIBP Internal Module

This internal module is manufactured by CAS Medical Systems, Inc. The module handles all circuitry involving blood pressure monitoring with the exception of the display and isolation circuitry. The module inflates the cuff, then uses the oscillometric technique to determine maternal blood pressure values and maternal pulse rate.

THEORY OF OPERATION, 118 CIRCUITRY

Power Supply Board (No. 8370) Circuitry

The Power Supply Board is comprised of four individual power conversion circuits delivering power to the Model 118 circuitry. The four separate power sources are categorized in Table 4-1.

The SYNC Oscillator Signal. In an effort to reduce specific system harmonics and overall system noise, the three switching regulator type power supplies on the Power Supply Board use a common oscillator signal sourced from the Ultrasound Board, No. 9613. The oscillator signal, called SYNC, is passed from J1-24 on the Ultrasound Board edge connector, to P/J 409 pin 8 on the Mother Board. The signal is then connected via a harness assembly to the Power Supply Board connector P/J 303 pin 1. An isolated ground called SYNCGND is paired with the SYNC signal and carried through the same connector circuit. SYNCGND arrives at the Power Supply Board connector P/J 303 pin 2. The oscillator frequency of the SYNC signal is 72 KHz.

The 5 Volt Buck-Type Switching Regulator. The 5 Vdc buck-type switching regulator is a dc-to-dc converter which operates in the current mode using transformer drive and an N-channel power MOSFET switching stage. The unregulated 22 Vdc input voltage for the 5 volt supply is sourced from the Model 118's main dc supply formed by the unit's main power transformer, T1, the full wave rectifier D1 and the main filter capacitor, C1. The components T1, D1 and C1 are mounted external to the Power Supply Board, on the Model 118's chassis. The 5 V power supply is controlled by U1, a pulse width modulator controller manufactured by Unitrode, Inc. U1 provides under-voltage lockout protection and current limiting protection to the main 5 volt output. When in the under-voltage or current limit mode, U1 shuts down the drive to the T3 transformer primary, effectively turning off the MOSFET Q1 and the 5 V output.

The 72 KHz switching frequency (derived from the Ultrasound Board) for the 5 volt power supply is decoupled by the first transistor stage, Q3, and buffered by the second transistor stage, Q12. Q12 then becomes the current source control for the oscillator input signal to U1, pin 4, R_T/C_T. The 72 KHz drive to U1 is processed, buffered and passed to U1's internal totem pole output pair at pin 6. U1 pin 6 drives the primary side of T3 at the 72 KHz rate, turning the MOSFET Q1 on and off at the same frequency. The snubber circuit comprised of D3, R13 and C10 provides attenuation for the inherent switching frequency spikes on Q1's output. The output of Q1 is LC filtered by L1 and C12 before being passed to the 5 volt circuits of the Model 118.

Regulation for the 5 volt supply is provided by U1. U1 pin 2 senses the 5 volt output then processes the stepped down level by its internal error feedback circuits. Potentiometer R1 is provided for output voltage adjustment. Control for the 5 volt power supply is provided by the previously mentioned under-voltage and current limit protection circuits internal to U1. Under-voltage is sensed at pin 7, V_{CC}. Under-voltage is triggered when pin 7 drops below 10 Vdc. Under-voltage protection will turn off when pin 7 exceeds 16 Vdc. Current limiting is controlled by pin 3, I_{SENSE}. Through a shunt network, pin 3 senses the secondary or "monitor" winding of T2. As the main 5 volt output current increases, pin 3 increases in voltage. When pin 3 exceeds 1 Vdc, over-current limit protection is turned on. When pin 3 drops below 1 Vdc, over-current protection is turned off. Over-voltage protection is provided by the zener diode clamp, ZD2, across the main 5 volt output. Voltage excursions above 5 Vdc are clamped to the 5 volt level.

Table 4-1. Power Supply Board Circuits

POWER SUPPLY	MODE	CLASSIFICATION
5 Vdc Supply	Current	Buck-Type Switching Regulator
±15 Vdc Supply	Current	Discontinuous Flyback Switching Regulator
7/20 Vdc Supply	Voltage	Buck-Type Switching Regulator
13-17 Vdc Supply	Linear	Adjustable Three Terminal Regulator

The ±15 Volt Flyback Switching Regulator. The ±15 Vdc switching regulator is a dc-to-dc converter which operates in the current mode using flyback-type transformer control. Q4 is an N-channel power MOSFET switching stage controlling the flyback principle on the primary side of transformer T1. Q4 is controlled by U3, a pulse width modulator controller manufactured by Unitrode, Inc. U3 is identical to U1 in the 5 volt power supply with the exception of a limited duty cycle for its output. The same protection level as the 5 volt supply is provided through U3's internal under-voltage and current limit protection. Current and voltage sensing for U3 take place on the primary side of T1. When in the under-voltage or current limit mode, U3 shuts down the drive to the MOSFET Q4, effectively turning off the ±15 V secondary on T1. The unregulated 22 Vdc input voltage for the ±15 volt supply is sourced from the Model 118's main dc supply formed by the unit's main power transformer, T1, the full wave rectifier D1 and the main filter capacitor, C1. The components T1, D1 and C1 are mounted external to the Power Supply Board, on the Model 118's chassis. The 22 Vdc input voltage is switched at 72 KHz, by Q4 through T1's primary. The 72 KHz signal is sourced from the output of the 5 volt power supply controller U1, and fed to U3 pin 4, R_T/C_T. The secondary side of T1 provides the balanced dual windings necessary for a symmetrical dual output supply. C16 and C17 provide the decoupled neutral for the plus and minus supply return. Output filtering is provided by the L/C components L2 /C13 for the minus side, and L3/ C14 for the plus side.

Regulation for the ±15 volt supply is provided by U3. U3 pin 2 senses the output of an error level detection circuit comprised of Q2, U4, R20, R24 and R72. The error signal is stepped down by the voltage divider set up by R31, R32 and R33. The level is then passed to the internal error feedback circuits of U3. Potentiometer R72 is provided for output voltage adjustment. Under-voltage is sensed at U3 pin 7, V_{CC}. Under-voltage is triggered when pin 7 drops below 10 Vdc. Under-voltage protection will turn off when pin 7 exceeds 16 Vdc. Current limiting is controlled by U3 pin 3, I_{SENSE}. Current sensing is accomplished by sensing the voltage drop across R42, a 0.1Ω resistor. The I/R voltage product is passed to U3 pin 3 through the current limit resistor R39. As the drive to Q4 increases, U3 pin 3 increases in voltage. When pin 3 exceeds 1 Vdc, over-current limit protection is turned on. When pin 3 drops below 1 Vdc, over-current protection is turned off.

The 7 Volt to 20 Volt Buck-Type Switching Regulator. The 7 Vdc and 20 Vdc buck-type switching regulator is a dc-to-dc converter which operates in the voltage mode. As its name implies, the supply has two output modes; 7 Vdc and 20 Vdc. The 7/20 volt supply is used for the strip chart recorder motor control. In the 7 volt mode, paper is advanced at the preset chart speed rate. The 20 volt mode is used to rapidly advance paper when the Model 118's front panel Paper Advance pushbutton is depressed. The unregulated 22 Vdc input voltage for the 7/20 volt supply is sourced from the Model 118's main dc supply formed by the unit's main power transformer, T1, the full wave rectifier D1 and the main filter capacitor, C1. The components T1, D1 and C1 are mounted external to the Power Supply Board, on the Model 118's chassis. Circuit control is provide by U5, an advanced regulating pulse width modulator manufactured by Unitrode, Inc. U5 provides under-voltage and current limit protection. The 22 Vdc input voltage is switched at 72 KHz, by Q5, an N-channel MOSFET driven by the open collector output of U5. The 72 KHz signal is sourced from the output of the 5 volt power supply controller U1, and fed to U5 pin 3, OSC.

The control signal selecting the 7 or 20 volt mode is sourced from the Model 118's Ultrasound Board. The signal, MOTVCTRL, arrives at the Power Supply Board's connector P/J 303 pin 6. MOTVCTRL is a high for the 7 volt mode, and an active low for the 20 volt mode. When high, Q7 is biased on by R59. Q8 is biased off allowing U5 pin 1 to sense the supplies' output voltage through the voltage divider resistor network R56, R50 and potentiometer R73. In this mode, the supplies output is 7 Vdc. Also in this mode, regulation is accomplished by the signal on U5 pin 1, which is sensing error signals on the supplies output. The potentiometer R73 is provided for output voltage adjustment. For the 20 Vdc mode, MOTVCTRL goes low, Q7 turns off, biasing Q8 on. With Q8 on, the R50, R73 network is shunted by R49. The voltage on U5 pin 1 is essentially the value of the voltage divider comprised of R56 and R49.

Under-voltage is protection is sensed at U5 pin 15, +VIN. When the voltage on pin 15 falls below 7.5 Vdc, U5 shuts down. The voltage must reach at least 8 Vdc for U5 to turn back on. Current limit protection is accomplished by sensing the voltage drop across R62, a 0.22 Ω resistor in series with the main output. The voltage drop across R62 is sensed by pin 4 (+CL), and pin 5 (–CL) of U5. When the voltage between pins 4 and 5 becomes 200mV or greater, the current limit protection circuit of U5 is actuated and an orderly shutdown is performed.

The 13-to-17 Volt Adjustable Three Terminal Regulator. The three terminal 13-to-17 Vdc regulator, U6, is an industry standard regulator operating in the linear mode. The supply output is dedicated to the strip chart recorder's thermal printhead. The output voltage of this power supply is set by adjusting R63 for the voltage required by a specific printhead. One voltage setting does not apply to all printheads, therefore, the output of the 13-to-17 volt supply will be different when compared to other units. Also, a printhead protection circuit is incorporated in the 13-to-17 volt supply. The circuit is comprised of the signal HDSHTDN, and the transistors Q9 and Q10. In normal operation, the signal HDSHTDN should be at 5 Vdc and enables the supply output line, VHD. If the HDSHTDN signal is low, the 13-to-17 volt power supply will remain off until the cause of the problem is removed. HDSHTDN is a software controlled signal.

Display Board (Manufactured by Planar)

The following technical information is a summary of the Display Board Circuitry. This information is provided to give the hospital biomedical engineer an overall summary of the Display Board's functions in relation to the host unit — to assist in isolating troubleshooting problems to the board level. This information is not intended to provide a complete circuit theory and should not be used to repair any problems on the Display Board itself. When a problem does exist with the Display Board, contact your Corometrics Service Representative for information about repair/exchange of the Display Board. The electroluminescent display is a 240 column by 64 row flat panel with a resolution of 48 dots per inch. The pixel aspect ratio is 1:1. A pixel is defined as the intersecting area between the column and row electrode. The four basic operational signals (VID, VCLK, HS, VS) originate on the Peripheral Board and pass directly to the Display Board via the Display Power Supply Board. (None of the signals are buffered or terminated within the Display Power Supply Board.)

Video data (VID), contains the serial pixel information to be displayed — the data originates as the output of U44 on the Peripheral Board. A pixel is lit as voltage is applied to the specific row and column electrodes. Data is supplied from left to right and from top to bottom. Bit number one is displayed as the pixel in the upper left corner of the display; bit number 240 is displayed as the pixel in the upper right corner of the display; and bit number 241 is displayed as the pixel directly beneath pixel 1, etc.

The vertical sync (VS), horizontal sync (HS), and video clock (VCLK) signals originate on the Peripheral Board as outputs from programmable logic device U19. The vertical sync signal (VS) is used to initiate a new frame scan. The horizontal sync signal (HS) is used to bracket the active pixel data for a horizontal scan line. The video clock signal (VCLK) is used to serially shift VID into the display; data latching occurs on the falling edge of the VCLK signal.

Operating voltage is supplied by the Display Power Supply Board.

Display Power Supply Board (Manufactured by Planar)

The Display Power Supply Board accepts a 5 V and 12 V input from the Peripheral Board and generates the high voltage section — not to exceed 235 V. Each Display Power Supply Board is calibrated together with the Display with which it will be used. When a problem exists with the Display Power Supply Board, contact your Corometrics Service Representative for information about repair/exchange of the Display Power Supply Board.

Ultrasound Board (No. 9613) Circuitry

Dual Channel Pulsed Doppler Ultrasound. The ultrasound circuitry has two channels; Channel A and Channel B. Each ultrasound channel generates 1.151 MHz (center frequency) pulsed Doppler signal. The ultrasonic sound waves emitted from the transducer crystals enter the maternal abdomen and create echoes when they encounter an interface between tissues of differing acoustic impedance. If the interface is moving either toward or away from the ultrasound transducer, the frequency of the reflected sound differs from the frequency sent from the transducer.

The Ultrasound Transducer. The ultrasound transducer uses nine (9) piezoelectric crystals; eight are arranged in a circle; the ninth is located in the center of the circle. The transducer housing is completely shielded to minimize the effects from external interference. The transducer transmits a group of pulses and then stops the transmission. After a short delay, the transducer begins receiving on the same crystals. The sequence repeats continuously.

When the signal is reflected and received by the transducer crystals, the reflected sound is converted to an electrical signal. After being filtered and amplified, the signal is split into two paths: ultrasound audio and ultrasound envelope. The audio signal is sent to the Peripheral Board for volume control. The ultrasound envelope is sent to the DSP Board.

The center frequency of the transmitted signal is 1.151 MHz with a pulse repetition frequency of 4 KHz (single channel use) or 2 KHz per channel (dual channel use).

The total transmit and receive process is 250 µs which is broken down as follows:

- 90 µs: transmit pulse-wave Doppler
- 40 µs: wait state
- 90 µs: receive reflected signals
- 30 µs: idle state

When both ultrasound channels are being used, Channel A will complete a 250 µs cycle while Channel B is muted; then Channel B will complete a 250 µs cycle while Channel A is muted.

Ultrasound Oscillator. The ultrasound oscillator is formed by the 4.604 MHz crystal X1, inverters in U19, and the timing components C95, C96, C97, and C98. The frequency of the oscillator may be finely adjusted by capacitor C97. The output of U19 (pin 8) is counted down by counters U13, U15, and U16.

The Digital Control Section. The digital control section of the Ultrasound Board is common to both Channel A and Channel B and is comprised of U19, PALs U17 and U18, and counters U13, U14, U15, and U16. Counters U13, U15, and U16 count down from the oscillator and provide sequencing inputs to PALs U17 and U18. An inverted version of the 4.604 MHz clock is used to clock PAL U18 so that PAL output changes have had one half of a clock cycle to settle.

Signals A/ and B/ are input to PAL U17 and U18 and provide information on the number of transducers connected to the monitor. If only one ultrasound channel is selected, U18 outputs the appropriate signals for that channel only, at a pulse repetition frequency of 4 KHz. If both ultrasound channels are selected, the rate for each channel is 2 KHz. If a simulator or Model 320/330 Telemetry System is connected, the board operates in continuous-wave mode.

Signal MODE is generated by counters U13, U14, U15, and U16 and used when both Channel A and Channel B are selected or when a telemetry system is connected. The MODE signal is ignored if only one signal (A/ or B/) is selected. When in use, MODE changes state every 1024 clock cycles after reset to alternately activate signals PIN1/ and PIN2/.

Signals PIN1/ and PIN2/ are used to control the pin diode switches which in turn select which channel is being transmitted and received. Since each channel is alternatively selected by time multiplexing, the frequency of operation for each channel is 2 KHz.

The signal TRANS is a square wave with a frequency of 1.151 MHz which controls the ultrasound transmitter circuitry. It is initiated four clock cycles after reset and continues up to 428 clock cycles. This signal is disabled when a simulator or telemetry system is connected to the monitor.

The signals DETQ and DETQ/ are 1.151 MHz signals, 180° out of phase with each other. They are used to activate the demodulator. The signals begin 640 clock cycles after the counter chain in reset and continue up to 1020 clock cycles.

CH-1/ and CH-2/ control the output of the demodulator to the track and hold filter of Channel A and Channel B, respectively. They are controlled by A/, B/, and MODE (similar to PIN1/ and PIN2/), however they are switched active low from 640 to 1020 clock cycles—the same timing as DETQ and DETQ/.

Signal CLR/ goes to a low state every 1151 clock cycles and then resets binary counters U13, U15, and U16.

Signal CW is a continuous wave 1.151 MHz square wave used with a simulator or telemetry system.

Voltage regulators VR2 and VR3 provide ±12 V to the ultrasound preamplifier, demodulator, and analog switch U1. The RC networks provide high-frequency noise rejection for PIN diode switching.

U1 is a quad analog switch capable of switching high current. The signals PIN1/ and PIN2/ control the switches which route the +6 V and –6 V to resistors R7 and R8 and consequently bias the PIN diodes on and off. These values are ±6 V instead of ±12 V due to the loading of the PIN diode biasing current.

Channel A PIN Diode Circuitry. If Channel A (CH-1) is selected, R7 is biased to –6 V and R8 is biased to +6 V. The anode of D2 is held at ground potential by L2.

The cathode of D2 will be approximately 600 mV since it is forward biased by the current through R7. The anode of D3 will be at ground potential due to the –600 mV at its cathode. The current through D3 will be 15 mA since R9 is approximately 400 Ω (6 V / 400 Ω = 15 mA). D4 and D5 will be off at this time since their cathodes are at +6 V and their anodes are at 0 V. The 15 mA flowing through D2 and D3 stores charge in them which is an order of magnitude greater than will be depleted when the transmitter drives the transducer. Thus, even though the transmitter has large voltage excursions, D2 and D3 will remain on and provide a low impedance path between the transmitter and the transducer. During reception of signals, these diodes provide a low impedance path to the preamplifier.

Channel B PIN Diode Circuitry. If Channel B (CH-2) is selected, R8 is biased to –6 V and R7 is biased to +6 V. The anode of D5 is held at ground potential by L3. The cathode of D5 will be approximately 600 mV since it is forward biased by the current through R8. The anode of D4 will be at ground potential due to the –600 mV at its cathode. The current through D4 will be 15 mA since R9 is approximately 400 Ω (6 V / 400 Ω = 15 mA). D2 and D3 will be off at this time since their cathodes are at +6 V and their anodes are at 0 V. The 15 mA flowing through D4 and D5 stores charge in them which is an order of magnitude greater than will be depleted when the transmitter drives the transducer. Thus, even though the transmitter has large voltage excursions, D4 and D5 will remain on and provide a low impedance path between the transmitter and the transducer. During reception of signals, these diodes provide a low impedance path to the preamplifier.

Transmission, Channel A or Channel B. Two channels are implemented, however, both channels share part of the same signal path. The ultrasound transmitter circuitry is formed by transistors Q1, Q2, Q3, and Q4, and associated components. Transmission is initiated by the signal TRANS. The gated 1.151 MHz burst causes Q1 to turn on and off, thus charging and discharging capacitor C2, producing a triangle-like waveform. The waveform is further shaped by the non-inverting amplifier circuit comprised of Q2, Q3, and Q4. Further shaping and buffering is provided by L1 and C5.

Reception, Channel A or Channel B. Two channels are implemented, however, both channels share part of the same signal path. When the signal TRANS goes low, the receiver preamplifier is activated. The receiver preamplifier consists of Q5, Q6, and Q7 and associated components. L4 and C15 form a series resonant tank circuit which provides an impedance match between the transducer and the preamplifier. This tank circuit has a voltage gain of approximately 38 dB. Transistors Q5 and Q6 form a cascode amplifier. Q6 is a dual FET which is connected in parallel to improve the signal-to-noise ratio of the preamplifier by 3 dB. The noise improvement occurs since the effective transconductance is doubled but the noise adds in quadrature. Inductor L5 and capacitor C16 form a parallel resonant tank circuit with an impedance of approximately 10 kΩ. The preamplifier has a gain of approximately 13 dB. Transistor Q7 splits the signal to supply a differential output to switch U2. Diodes D6 and D7 protect Q6 and clamp the voltage across C15 during transmission. Diodes D8 and D9 limit the voltage across capacitor C16 and speed overload recovery.

Quad high speed analog switch U2 is configured as a balanced ring demodulator. It is driven from the preamplifier's differential outputs. Signals DETQ and DETQ/ turn the switches on and off at the same frequency as the transmitted signal. Any return signal of the same frequency will produce either DC or 0 V between capacitors C23 and C24. Due to AC coupling at a later stage, no output would be produced by a DC level. A difference frequency (Doppler shift frequency) must be present to produce an output. U3 buffers the differential signal, converts it to a single-ended signal and amplifies it by 26 dB. U3 is active only one third of the time. During the switch-off time, capacitor C23 is discharged by R20 and R22 while C24 is discharged by R21 and R23 to avoid crosstalk between Channel A and Channel B since the signals for both channels are multiplexed over the same signal path.

U3 drives analog switch U4 through R28. Signals CH-1/ and CH-2/ steer the demodulated output to the appropriate filter channel (Channel A or Channel B) when U3 is active. Switch U4 is kept inactive when U3 is inactive. Capacitor C29 holds the demodulated signal for Channel A between samples; C28 holds the demodulated signal for Channel B between samples.

Channel A Filtering. The main filters for Channel A are bandpass filters consisting of U5 and associated components. The 3 dB points are at 100 Hz and 300 Hz with rolloffs of 24 dB/octave for both high and low frequencies. Variable resistor R32 is used to set the overall gain between the signal's input and TP1 to 32 dB. The output of the main filter (U5, pin 8) is then split between the ultrasound audio circuitry and the ultrasound envelope circuitry.

Channel A Audio Circuitry. The output of the main filter (U5, pin 8) feeds a filter chain for audio circuitry. The audio signal is full-wave rectified by two sections of U6 and associated components before being bandpass filtered by one section of U8; the resulting signal is doubled in frequency. The output is then buffered by a second section of U8. Audio signal AUD A is then sent to the Peripheral Board for volume control; audio signal A BUFF is routed to the rear panel.

Channel A Ultrasound Envelope. The output of the main filter (U5, pin 8) feeds a filter chain for counting and processing the fetal heart rate. The signal is processed for automatic gain control (AGC) by AGC chip U7. The signal is then high-pass filtered, half-wave rectified by one section of U6, and then low-pass filtered by a second section of U6. The ENV A signal is then routed to the DSP Board where the heart rate is calculated.

Channel B Filtering. The main filters for Channel B are bandpass filters consisting of U9 and associated components. The 3 dB points are at 100 Hz and 300 Hz with rolloffs at 24 dB/octave for both high and low frequencies. Variable resistor R70 is used to set the overall gain between the signal's input and TP2 to 32 dB.

Channel B Audio Circuitry. The output of the main filter (U9, pin 8) feeds a filter chain for audio circuitry. The audio signal is full-wave rectified by two sections of U10 and associated components before being bandpass filtered by one section of U12; the resulting signal is doubled in frequency. The output is then buffered by a second section of U12. Audio signal AUD B is then sent to the Peripheral Board for volume control; audio signal B BUFF is routed to the rear panel.

Channel B Ultrasound Envelope. The output of the main filter (U9, pin 8) feeds a filter chain for counting and processing the fetal heart rate. The signal is processed for automatic gain control (AGC) by AGC chip U11. The signal is then high-pass filtered, half-wave rectified by one section of U10, and then low-pass filtered by a second section of U10. The ENV B signal is then routed to the DSP Board where the heart rate is calculated.

Multifunction Board (No. 7931) Circuitry

The Multifunction Board accepts unprocessed ECG and UA signals and routes them to the DSP Board for computation. This board also contains mode line buffering, the leg-plate signal generator, telemetry/ simulator output buffering, and the audio output amplifier.

The ECG Front End and Isolation Circuitry. The 116 ECG circuitry consists of an electrically isolated pre-amplifier for patient-connected electrodes and signal filtering dependent on the Model 118's mode of operation.

The Isolation Circuitry. The ECG front end is configured as a basic isolated instrumentation amplifier with a gain of 60 dB, composed of op amps U15, U16, and U1. Coupling capacitors C17 and C26 limit the low end frequency response of the amplifier to 1 Hz and minimize the amplifier's DC offset. The input to the instrumentation amplifier is R/C filtered (R9/C14, R24/ C21) to help remove high frequency noise. R9 and R24 also help to reduce current output to the patient in case of a device failure. Diodes D5, D6, D7, and D8 serve to limit the differential input voltage and the output current in case of a device failure. Two 22 MΩ resistors (R11 and R21) connect both input leads of the amplifier to the isolated negative supply to ensure saturation of the input stage if left unterminated (not connected to patient). This, in effect, turns off the amplifier, preventing false noise triggering when not connected to a patient. Dual op-amp U9 is used to invert and amplify the common mode voltages (located at the junction of R14 and R22) and send it to the leg plate as the right leg drive. One section of U9 is configured as an integrator, the second half as a buffer with R3 and R2 used to limit output current in case of a device failure. High impedance amplifier U17 is used to couple system ground through capacitor C33 to the shield line of the leg plate cable. Isolation amplifier U2 is used to couple the isolated ECG output from the instrumentation amplifier to main system circuitry.

The Isolated Power Supply. The isolated power supply is a DC-to-DC converter providing the ±12V isolated supply voltages for the isolated patient connected circuitry.

The 36 KHz clock signal from the Ultrasound Board is fed to monostable U3 (pins 2, 9). Each half of the monostable is configured to trigger from different edges of the clock signal.

The output of the monostable U3 (pins 5, 13) causes the driver transistors (Q10, Q2 or Q3, Q1) to alternately pulse current into each half of the center tapped primary of T1. Voltage produced at the secondary winding of T1 is rectified by D1-D4 and filtered by C4 and C8. Three-terminal voltage regulator VR1 provides the regulated +12 V; three-terminal voltage regulator VR2 provides regulated -12 V.

The ECG Filtering. The output of the isolation amplifier U2 is low pass filtered by a 100 Hz 2-pole active filter composed of one section of quad op amp U4. The output of the low pass filter connects directly to both sections of dual op amp U5 which serves as the buffer amplifiers for the 60 dB ECG and 80 dB ECG outputs. The 60 dB section is configured as a unity gain amplifier; the 80 dB section is configured as a 20 dB gain non-inverting amplifier. The low pass filter also connects to the input of the MECG amplifier, a section of op amp U4, which provides a high-pass function at 8 Hz, an additional pole of low pass and an additional 14 dB of gain. The FECG processing takes the 100 Hz low pass output and high passes it at 25 Hz through a 3-pole active filter comprised of one section of U4. The output of the high pass filter is further amplified by 24 dB in an additional section of U4 which also adds an additional pole of low pass.

The Pressure Channel. The circuitry in the pressure channel detects the presence of a strain gauge or tocodynamometer is plugged into the front panel UA connector, produces the IUPEN or TOCOEN Enable, and also provides the necessary filtering and amplifier circuitry. The circuitry also generates a +4 volt excitation voltage for either a strain gauge or tocodynamometer bridge.

A section of U12, along with transistor Q6, form the regulated 4.000 volt reference for the pressure channel transducer (BRGEXCIT). U12 provides the reference voltage for emitter-follower Q6. The feedback for the op amp is taken from the emitter of Q6 to provide proper regulation and stability. The voltage drop across collector-resistor R77 or Q6 is detected by a section of op amp U12 which is configured as a comparator. When current is drawn by the pressure transducer, the voltage at the collector of Q6 will drop below the threshold of the comparator causing it to turn off transistor Q5. Q5 is used as a level translator which converts the comparator output to TTL. The high TTL level at the collector of Q5 (PRESSEN) is detected in the mode decoder PAL U21 as a pressure channel enable.

The +4-volt reference is applied to the pressure-transducer bridge excitation nodes. Pressure variation cause a differential voltage to appear across the remaining two nodes according to the formula:

V (differential) = SGF x V (ref) x Pressure (mmHg)

The constant, SGF, is the "Strain Gauge Factor" which depends on the transducer being used. The SGFs for Corometrics' transducers are as follows:

- Strain Gauge = 5 μV/V/mmHg
- Tocodynamometer = 2.5 μV/Vg

NOTE: Tocodynamometer measurements are only relative measures of uterine pressure. Strain gauge measurements are absolute measurements of intrauterine pressure in mmHg.

The differential voltage from either a strain gauge or tocotransducer is filtered and applied to an instrumentation amplifier with a gain of 63.5 dB, consisting of dual op amp U10 and op amp U11. The input is R/C filtered by R85/C63 and R88/C64 to reduce high frequency noise pick-up.

The output is low pass filtered at 10 Hz using a two-pole active filter composed of a section of quad op amp U12 (pins 12, 13, 14). The output of the low pass filter connects through FET switch U18 to a summing amplifier composed of a section of U12 (pins 5, 6, 7). The summing amplifier inserts a fixed offset to the low passed pressure signal for proper scaling, and will also add an additional fixed offset equal to 50 mmHg through the FET switch U18 during system test. The output at TP 19 (UA) is sent to the DSP Board.

The Mode Enable Circuit. The mode inputs are decoded in PAL U21 which provide decoded mode information to the rest of the system. U21 is also used to buffer the 36 KHz clock from the Ultrasound Board and gate the DET clock from the Ultrasound Board to the telemetry/simulator buffer U22.

The telemetry/simulator buffer consists of transistor Q13 which provides a level shift to +15V from the TTL output of U21, a phase shift network consisting of R151, R149, L1, C101, and the output buffer amplifier U22. This stage provides the transmit carrier to the simulator and the telemetry units which is normally available in a CW system in the form of a transmit crystal drive, but missing in a pulse system where the receive and transmit line are common. The telemetry and simulator enables, when active, will cause U21 to put the Ultrasound Board into a CW operating mode, and enable the buffer circuitry by allowing the CW signal from the Ultrasound Board to pass to the buffer input.

The Legplate Tester. The leg plate test generator consists of counters U6 and U7, NAND gate U14, and dual flip-flop U13. The 36 KHz clock signal from the Ultrasound Board is used to advance counters U6 (pin 1) and U7. The outputs of these counters are decoded in NAND gate U14 which provides the clock for one half of dual flip-flop U13 configured as a divide by two. The other half of U13 is used to delay the decoded output of U14 by one clock cycle providing the reset pulse to the counters. The 2 Hz square wave output of U13 (pin 5) is wave shaped by D19, R135, C95, and R136 and sent as the simulated 120 BPM test signal to the rear panel leg plate test connector.

The audio output amplifier. The audio output amplifier consists of op amp U8 and driver transistors Q7, Q11, Q4, and Q12. U8 is configured as a unity gain inverting buffer which level shifts the input and provides the drive for the output transistors. Transistors Q7-Q11 and Q4-Q12 are configured as discrete Darlington current drivers. The output of the driver through capacitor C92 (SPKOUT) is sent to the rear panel speaker. The feedback for buffer U8 is taken at the junction of the output transistors to provide accurate tracking of the input signal and reduce crossover distortion in the output. To provide the necessary voltage swing at the output, both U8 and the output transistors are operated from the unregulated +22 V supply. The negative supply for U8 is derived from the voltage drop across Zener diode D18 providing -3 V to the negative supply lead of U8. This allows the output of U8 to swing to 0 V, increasing the total output swing of the amplifier by approximately 2 V. Also, the input offset to U8, provided by R120 and R121 is shifted lower to utilize the increase in output swing in the negative direction.

Peripheral Board (No. 10621) Circuitry

Device selection. Device selection on this board is accomplished by decoding enable signals from the CPU Board (I/OSEG1* and I/OSEG2*) along with buffered address bits BA1-BA4. This is done with demultiplexer chips U65 and U66. The outputs of U65 in conjunction with the buffered read (BLRD* and BURD*) and write (BLWR* and BUWR*) strobes provide the chip selects for the various port buffers, latches and other control devices used on the board. U66 is used to provide the chip selects for the D/A circuitry associated with the central connector outputs and the audio volume controls.

Display Interface Circuitry. Pixel data and address information originates from the CPU board. Pixel data from the CPU board is written to dual port RAM (DPR) chip U37. The column address from the DPR is latched into counters U55 and U56; the row address from the DPR is latched into counters U57 and U58. (The row and column counters can be independently configured by the CPU to auto-increment after each access to DPR U37.) A bank of counters (U34, U35, U36, U42, U43), along with PAL U19, function as the display controller. Counters U34 and U42 generate row addresses while counters U35, U36, and U43 generate the column addresses. PAL U19 decodes the row and column addresses to generate the display timing signals. The DPR chip U37 is a shared memory device which can be accessed by the CPU board and the display controller circuitry. The signal READY is used to arbitrate bus contentions when the CPU Board and the display controller attempt to access U37 at the same time. When READY is high, U37 can be accessed; when READY is low, the bus cycle is extended until U37 is available. Parallel-to-serial shift register U44 is used to convert the parallel data in U37 to a serial format for the display. Programmable logic device U19 creates the three operational signals needed by the display to input the serial data: vertical sync (VS), horizontal sync (HS), and video clock (VCLK).

Rear Panel Switch Buffers. Buffers U62, U63, and U64 are used to connect the front and rear panel switches to the buffered CPU data bus.

Latch U24 is used to generate control signals for the DSP Board to arbitrate use of the shared memory (C25RSET* , SM68000*, and DTA-AVA*), and provides the control signal to the Multifunction Board for adding 50 mmHg to the pressure channel during UA test (UATEST*).

Buffers U45 and U46 allow the CPU to read the system configuration switches located on the board, and U45 also reads the arbitration signals generated at the DSP Board for controlling shared memory (SMC25* and DTARCV*).

Keyboard Interface Circuitry. U59, U6, U49, and U60 comprise the keyboard interface circuitry. The data signals from the keyboard (KBD0-KBD4) are latched into U59 upon application of KBDSTB* from the keyboard. The data latched into U59 may be read at any time by the CPU. KBDSTB* also sets flip-flop U6 asserting KBDIBF which acknowledges reception of data to the keyboard. The CPU resets U6 by a port line on U60, negating KBDSTB* which allows the keyboard to send new data. Latch U60 is also used to generate the keyboard control signals KBDINVL*, KBDBUSY*, and KBDRST as well as central connector outputs MARKOUT*, CHCKPAP*, HR1XFER, and HR2XFER. Buffer U49 is used to read the KBDMARK* and KEYPAD* signals along with the ultrasound enable lines (US1SEL* and US2*).

Strip Chart Recorder Interface Circuitry. Printed data is sent to the printhead serially through parallel loaded shift registers U52 and U27. Data is loaded into the shift registers from the CPU and then clocked out serially when counters U29 and U38 are activated. U29 and U38 provide the shift register clock and printhead clock (DOTCLK). When terminal count is decoded by gates in U7 and U16, a reset is generated by flip-flop U8 halting the counters until the sequence is initiated again by the CPU. The clock for the counters is provided by U15 which divides down the off-board 2.5 MHz signal. U15 also provides the clock for counter U14, which is used to provide a time out signal stopping the printhead strobe and turning off the printhead supply if the strobe remains on too long. Latch U25 provides the control signals from the CPU for the recorder circuitry. It is used to initiate the loading of the printhead, generates the load (LOAD*) and strobe (PHDSTB*) signals for the printhead, enables the recorder motor (MOTEN), generates the step pulse for the recorder motor at normal run speeds, controls the recorder motor running voltage (MOTVCTRL), and selects between the latch generated motor clock and the output of an off-board timer (used for high speed paper advance) through multiplexer U13 (MOTCLK). Buffer U26 allows the CPU to read the state of the recorder control signals as well as the outputs of comparator U17 which detects the paper out and paper low photo sensors (POUT DET, PLOW det) and the door open switch (DOOR).

Digital-to-Analog Conversions. U21, U22, and U23 are dual D/A converters that are used to generate the analog mode, heart rate, and pressure outputs for the central connector. The data loaded into each half of the D/A's by the CPU will independently adjust the output current of each section. An op amp is configured on the output of each D/A section to provide the current to voltage conversion using internal feedback components in the D/A. A second op-amp is added to provide the necessary scaling for the central outputs. The mode outputs (HR1 MODE, HR2 MODE, UA MODE) are scaled to provide a range of ±10 V, while the heart rate (1.2HR1, 1.2HR2) and pressure (1.2PRESS) outputs are adjusted with offset and gain controls for levels of ±1.2 V. A buffered voltage reference is provided for each D/A section from the +10 V supply.

Digital Volume Control. The four audio channels (US1, US2, ECG beep, alarm tones) are controlled by a similar dual D/A configuration. Each channel of audio is fed into a reference input of the dual D/A U20 and U79. Data loaded into each section of U20 and U79 by the CPU then controls the ratio of output current to reference voltage, providing a CPU controlled volume control. The output of each section of U20 and U79 is current-to-voltage converted by sections of U8 for U20 and U10 for U79, then input to analog switch U1. Switch control of U1 is handled by latch U47 which selects the inputs on each channel to be summed in an op amp stage of U8. The signal (AUDIO-OUT) is then routed to the Multifunction Board audio amplifier. The write strobe used by both the central and audio D/A's is generated by windowing the system write strobe using shift register U32 and gate U18. U32 and U18 hold off the application of the write strobe for 50 ns after a valid select occurs and terminate the strobe before the end of the select. This provides the proper setup and hold time for the D/A's.

The Communication Circuitry. The communication circuitry provides one of the external RS-232C ports and the COROLAN output. The main control device is U68, a dual UART. Chip select, read strobes, and write strobes for U68 are decoded in PAL U67 which converts the system strobes and selects to the timing required by the UART. One channel of U68 is connected directly to RS-232C buffers U73 and U78 forming the dedicated RS-232C channel. The other U68 channel connects to the COROLAN Manchester transceiver U72. An output latch of U48 provides the COROLAN active LED output. Buffer U77 allows the CPU to read the COROLAN bed address. U75, U6, and associated gates provide an access hold off timer

which prevents the CPU from accessing the UART for 8 clock cycles after the last chip select. The second RS-232C port circuitry is located on the CPU board. UART U50 provides the RS-232C communications for the internal SpO_2 and NIBP modules. The timer output of U50 is also used to provide the audio tones used for ECG beeps and other alarms.

CPU Board (No. 10622) Circuitry

Processor. The CPU Board is based on an MC68000 processor (U13) clocked at 16 MHz. The processor is supported by two 128k x 8 static RAMs (U36, U37), two 1M x 8 EPROMs (U38, U39), and two 2k x 8 NVRAMs (U34, U35). U34 also includes the system real time clock.

Clock Circuitry. The system clock circuitry consists of oscillator OSC1 and divider U25. The divider divides the 32 MHz clock signal into 16 MHz for the processor (U13), 8 MHz for the DMA controller (U15), and 4 MHz for the multifunction peripheral chip (U31).

The Reset Circuitry. The reset circuitry consists of half of dual monostable U18, and two open collector AND gates in U8. On power up, the delayed rising edge of the +5 V supply fires off U18, generating a low going 100 ms pulse. The output of U18 connects to the RESET* and HALT* inputs of processor U13 through the AND gates in U8 which also serves to combine the output of the watchdog reset circuitry (WDRESET*). The output of one gate of U8 connects to RESET*; the other gate's output connects to HALT*. When U18 generates the 100 ms pulse on power up, or if the watchdog fires off, both the RESET* and HALT* lines of the processor are pulled low causing a processor reset to occur. The RESET* line of U13 is buffered by a gate in U22 and used as the main system reset (SYSRS*) by all other components in the system.

The Watchdog Circuitry. The watchdog circuitry consists of counters U16 and U17, NOR gate U32, and monostable U18. The counters divide down the 16 MHz clock to provide a rising edge 53 ms after the counters are reset. The output of watchdog counter U17 is combined in a NOR gate of U32 along with the HALT* line from processor U13 to provide the trigger for watchdog monostable U18. If the counters are not reset (WDCLR*) within 53 ms from the previous reset, the output of counter U17 goes high causing the output of gate U32 to go low, causing monostable U18 to generate a 1 ms low going pulse (WDRESET*). This generates a processor reset condition at the outputs of AND gates U8 as indicated above. U13 pulling the HALT* line low from a processor error, will also cause U18 to generate WDRESET*. The watchdog is held from firing by the processor periodically resetting counters U16 and U17. This is done by detecting a falling edge from configured output line I6 of multi-function chip U31. A delayed and an inverted version of the U31 output are connected to each input of a NAND gate in U48. At each falling edge, the output of U48 will produce a low going pulse of approximately 100 ns (WDCLR*) which reset the watchdog counters. WDCLR* is also used to clear a R/S flip-flop composed of two gates (DLSPRS*) which blanks the display when first set by a system reset (SYSRS*).

The Wait State Generator. The wait state generator consists of shift register U20, multiplexer U21, and encoder U43. Upon application of address strobe (AS*) from the processor, if CYL-RST* is high, the output of a NOR gate in U23 will go high causing the reset on shift register U20 to be negated, allowing it to shift highs through its outputs at the processor's 16 MHz clock rate. The outputs of U20 are each connected to an input of multiplexer U21 which is used to select the shift register output sent to the processor DTACK* input. The output selection of U21 is controlled by priority encoder U43 which produces the select address for the multiplexer. Pulling low any input to U43 will cause it to produce a specific address at its outputs that correspond to the input pulled low. The time from AS* low to DTACK* low determines the number of wait states of the processor. By pulling low a specific input of U43 at the start of the processor cycle (AS* going low), selected outputs of the shift register are transferred to the output of the multiplexer, altering the timing between the falling edge of AS* and the falling edge of DTACK*, thereby making different wait states available to the processor. Connecting chip selects through open collector output devices to the inputs of U43 allows each system device to select the wait state needed for proper chip operation. The default selection is set at one wait state by inverting the +5 V signal with an inverter from U24 and applying the inverted output to the 1 select input of U43. The wait state generator can be reset during a shared memory access by pulling CYL-RST* low which resets shift register U20. When the signal is negated, a new complete DTACK* cycle is started. CYL-RST* is generated in the shared memory access circuitry on the DSP Board. The READY signal from the Peripheral Board, when negated, removes the clock from U20 through an AND gate in U30 extending out the DTACK* time. This signal is removed if time between

accesses of the USART is too short or if access collision occurs with the display DPR. The wait state generator is disabled for chip selects and interrupt cycles for the DMA controller U15, multifunction chip U31, and DUART U50 on the Peripheral Board which generate their own DTACK* signal. This is done by decoding the chip selects and interrupt acknowledge signals for these devices in NAND gate U9. During the chip select or interrupt cycle the output for U9 goes high, tri-stating the output of U21 which normally provides DTACK*. The output of U9 also enables the last output of shift register U11 through a gate in U27. U11 clocks through the last bit from shift register U20 in the wait state generator using the 2.0 MHz clock. If DTACK* is not asserted before a high is clocked through U11 (4.5 µs), BERR* is applied to the processor from the output of U27, signaling a bus error.

The Interrupt Controller. The interrupt controller consists of encoder U46, demultiplexer U6, and NAND gate U27. Priority encoder U46 generates the interrupt priority level to the processor through the IP0-IP2 interrupt control lines. The interrupting device pulls low one of the inputs to U46, which then asserts the corresponding priority code to the processor. The interrupt acknowledge cycle is detected by a NAND gate in U27 which decodes the function code outputs FC0-FC2 of the processor. When the function code for an interrupt acknowledge cycle is detected, the output of U27 will go low (IACK*). The IACK* signal is used as an enable for demultiplexer U6 which decodes the lower address bits of the processor during the acknowledge cycle, and produces the appropriate acknowledge for the device of the interrupt being serviced.

Address Decoding. The address decoders consist of PAL U26 and PAL U33. PAL U26 decodes the address bits A13-A19, along with the enable from U6, IACK*, and the LOCK signal from multifunction chip U31. U26 produces the chip selects for the on-board PROMs U38 and U39, RAMs U36 and U37, and NVRAMs U34 and U35, and also produces the enables for shared memory (SMEMEN*), data and address buffers/ transceivers U49, U52, U53, U51, U54, U55, and U56 and for PAL U33 (I/OEN*). IACK* disables the chip selects during interrupt acknowledge cycles, and LOCK inhibits processor access to NVRAM unless pulled low. SCCIACK* is also decoded in this PAL to allow enabling of the data transceivers to the Peripheral Board during a USART interrupt acknowledge cycle so interrupt vectors can be passed to the processor. PAL U33 provides the final level of address decoding. It decodes the lower address bits A1-A9, along with the enable line from U26 to provide the chip selects or enables for the DMA controller U15 (DMAEN*), multifunction chip U31 (MFPEN*), the Peripheral Board USART (SCCEN*), DUART (UARTEN*), and the port decoder enables for the Peripheral Board (I/OSEG1*, I/OSEG2*, and I/OSEG3*).

The Multifunction Peripheral Controller Chip. The multifunction peripheral chip U31 contains four timers, a UART, and eight configurable I/O pins. Two of the timer outputs (TIMER1 and TIMER2) are used by the system for high speed paper advance clock, and to provide the 1 KHz ECG beeps and other alarm tones. The remaining two are used by the processor as time keepers. U31 also serves as a secondary interrupt controller by configuring six of the I/O lines as latched inputs (I/O0-I/O5) which either cause U31 to generate an interrupt or are simply polled by the processor. These input signals are generated by different circuitry blocks on the Peripheral Board and the DSP Board. The remaining two I/O lines are configured as outputs which provide the LOCK signal to address decoder U26, or generates the falling edge needed to produce the watchdog reset at U48. The clock for the UART (2.46 MHz) as well as the USART on the Peripheral Board is generated by gates in U48 and crystal X1. The clock signal is buffered by U30 before being sent off the board. U1 and U2 provide the necessary level shift to and from RS-232C levels for the UART. This UART provides the second RS-232C channel for J110 communication.

Direct Memory Access Controller. The DMA controller (U15) provides direct memory to device data transfer. Upon a request sent by the USART (REQ*) on the Peripheral Board, the DMA gains control of the address and data bus of the processor, The DMA generates and responds to all the same control signals as the processor when controlling the system buses. After gaining bus control, the DMA first accesses the data stored in memory then, after storing it in an internal register, accesses and transfers the data to the USART before relinquishing control of the buses. The address lines A8-A23 of the DMA are common pins with the data lines D0-D15 so the DMA, before performing a data transfer, must latch these address bits in latches U28 and U40. After latching the address bits, the DMA enables data transceivers U29 and U41 connecting the data bus to the DMA. Transceiver U14 connects the upper data bits (D8-D15) to the lower data bits (D0-D7) allowing the DMA to do a data transfer

between upper and lower bytes. The DMA can also be used in the same manner to perform device-to-memory or memory-to-memory data transfer.

Read/Write Strobe Logic. OR gates in U12 provide the upper and lower read and write strobes used by the on-board memory and off-board peripheral devices. These signals are a combination of the processor upper and lower data strobes (UDS* and LDS*) and the processor write strobe (WRITE*). By inverting the WRITE* signal and ORing it with the UDS* or LDS*, the URD* and LWR* signals are generated. ORing WRITE* directly with the data strobe produces UWR* and LWR*. These read/write strobes along with AS* are buffered by U50 before being sent off board.

Address/Data Bus Buffers. Buffers U52 and U53 are used to buffer the address bus sent to the DSP Board for accessing shared memory. Transceivers U55 and U56 perform the same function for the data bus. U49 is used to buffer the address bus to the Peripheral Board, and transceivers U51 and U54 buffer the data bus to the peripheral board. These devices are held tri-state until valid chip selects for the board they support occur.

DSP Board (No. 7937) Circuitry

The Analog Input Section. The analog input section of the DSP Board consists of analog multiplexer U33, buffer amplifier U34, A/D converter U35, reference buffer U56, digital data buffers U4 and U20, and latch U5. The DSP Board processor (TMS320C25) U43 utilizing latched outputs of U5 address the multiplexer U33, selecting the input to be sampled. Once addressed, the multiplexer connects the selected input to analog buffer U34 which provides the input to the A/D converter. The A/D converter is configured in a stand-alone format (outputs always active). The processor reads the output data and status bit of the A/D, along with the multiplexer address bits through buffers U4 and U20. When the status bit becomes valid, the processor accepts the converted data. Data conversion is started by the processor doing a write to the port address allocated for read buffers U4 and U20. The convert pulse is generated in a gate of U37, and is time extended to approximately 250 ns by using a gate in U39 and additional R/C delay elements. Op amp U56 is configured as a buffer amplifier and is used to buffer the +10 V reference from the A/D. The output of U56 provides the reference input, and offset input to the A/D, as well as the input reference to the +10 V and -10 V supplies.

Memory Configuration. The memory configuration of the processor is divided into three distinct groups: program memory, data memory, and I/O memory; each sharing the same address and data buses but using different strobe signals (PS*, DS*, and IS*) to determine which is being actively cycled. The address decoders for each group must also utilize these strobes or combinations of strobes when providing chip selects to the memory or I/O devices. Decoders U9, U11, U45, and U41 provide the address decoding for the different memory groups. U9 is used to provide the chip select for the program PROMs U25 and U27. It decodes address bits A13-A15 along with the PS* strobe and the read/write line R/W*. The R/W* line is used to disable the PROMs during a write cycle. The Y0 output of U9 is used as the PROM chip enable, and the combination of that signal with the STRB* from the processor in an OR gate of U54 provides the output enable for the PROMs. The STRB* signal is used by the processor to signal that the data bus is ready to receive data for a read operation, or that data present on the data bus is valid for a write operation. U11 provides the chip select for the combination program/data memory RAMs U10 and U26. It also decodes address bits A13-A15, however it uses a combination of the PS* and DS* strobes generated in a gate of U55 to enable the decoder output. This allows both program and data memory to access the RAM. The Y1 output of the decoder is used as the chip enable of the RAMs and this line is ORed in a gate of U54 with the STRB* signal to provide the RAM output enable as was done with the program PROM. The processor R/W* line is also ORed with the STRB* in a gate of U54 to provide the write signal to the RAM. U45 decodes the A11-A15 address line along with the DS* strobe to generate the chip enable for the shared memory. The decoder U41 provides the port selects for the board I/O by decoding address bits A0-A3 and the IS* strobe. The port selects, in combination with R/W* are used to generate the chip selects for the I/O data buffers and latches. Buffer U6 is used by the processor to read the state of the mode lines (US1*, US2*, FECG*, MECG*, TOCO*, and INT/EXT*) and to read the shared memory arbitration signals from the Peripheral Board (SM68000*, DTA-AVA*). Latch U5 provides the addressing for the input multiplexer and also generates the signals sent to the Peripheral Board for the arbitration of shared memory (DTA-RDY*, DTARCV*, and SMC25*). Latch U21 is used to control the status LEDs on the board that indicates states of the processor operations, as well as generating the heart rate transfer signals to the CPU Board (I/O3* and I/O4*).

Shared memory. Shared memory consists of high speed RAM U15 and U31, data transceivers U14, U16, U30, and U31, and buffers U50, U51, U52 and U53. Buffers U51 and U52 are used to transfer the address bus, enables, and read/write strobes from the CPU Board to the shared memory. These buffers are tri-stated when the DSP processor has access to the memory or if the CPU Board is not doing a shared memory access. Transceivers U32 and U16 serve the same function for the CPU data bus, with the buffered CPU WRITE* line controlling the data direction of the buffers. Buffers U50 and U53, along with transceivers U14 and U30 perform the same task in connecting the DSP address and data bus to the memories. These buffers and transceivers are also tri-stated when the processor is not accessing the memory. Should both the CPU Board and DSP processor attempt to access the memory at the same time, OR gates from U47 will remove the enables from the CPU side of the shared memory, turning off their associated buffers and transceivers, and allow the DSP processor access. In addition, this circuitry will assert CYL-RST* preventing the CPU Board processor from completing the memory cycle until the DSP processor has completed its memory access.

Reference Voltage Circuitry. The +10 V and -10 V supplies are also located on this board. Utilizing the buffered 10 V reference from the A/D at U56, this reference is buffered (or inverted in the case of the –10 V supply) by op amps in U2, which drive transistor emitter-followers Q1 and Q2. Feedback for the op amps is taken at the emitters of the transistors to ensure output accuracy and stability. The selection of 180 ohms in the collector leads of the transistors limit the current output of each stage to about 18 mA.

Nellcor SpO_2 Module Circuitry

The internal SpO_2 module is manufactured by Nellcor, Inc. The following technical information is a summary of the module's circuitry. This information is provided to give the hospital biomedical engineer an overall summary of the module's functions in relation to the host unit — to assist in isolating troubleshooting problems to the board level. This information is not intended to provide a complete circuit theory and should not be used to repair any problems on the module itself.

When a problem does exist with the module, contact your Corometrics Service Representative for information about repair/exchange of the module.

LED Driver Circuitry. This circuitry controls the on and off pulsing of the infrared and red LEDs at the measurement site. Signals REDLED/ and IRLED/ alternately close FET switches U4A and U4B, respectively. The LED drive voltages are developed by dual DAC U1. The LEDs operate in a four-phase sequence as follows:

- 184.5 µs: infrared LED on
- 184.5 µs: both LEDs off
- 184.5 µs: red LED on
- 184.5 µs: both LEDs off

Transistors Q1, Q2, Q3, Q4, Q5, and Q6 control the drive current switching. The four-phase LED drive signal is routed to LED driver U3A. The resulting drive potential is coupled equally to both sides of the bridge circuit via R31 to Q4 and R36 to Q3. Signals IRLED/ and REDLED/ are pulsed low to cause their respective LEDs to illuminate. When both lines are a logic high, all bridge transistors are turned off. The infrared LED is illuminated when signal IRLED/ is pulsed low. The red LED is illuminated when the signal REDLED/ is pulsed low.

Input Source Selection Circuits. The sensor is connected directly to the Nellcor module; the Model 118 does not provide an external preamplifier. Two inputs are handled by this circuitry. The SAT signal, developed by the photodiode in the sensor, enters through JP1 (pins 1 and 4). Preamplifier U8 is used as a current-to-voltage converter for the photodiode current. The signal is then coupled through U10A to the input amplifier and synchronous detector circuits. The wavelength of the red LED is derived from the RCAL resistor in the sensor which connects between pin 6 of JP1 and ground to become part of a voltage divider with R16. Power for this divider is a 2.5 V reference on the Nellcor module. This calibration voltage (VCAL2) is communicated to the DAC via buffer U21B.

Input Amplifier and Synchronous Detector. The SAT signal is conditioned by the input amplifier and the synchronous detector to provide signal gain and reduce or eliminate the effects of ambient interference. Negative peak detector U7 is employed to monitor the SAT signal while it is still DC-coupled; it produces a DC output proportional to the maximum negative excursion of the SAT signal pulses. If the negative excursions of the SAT signal exceed –10 V, the modules's microprocessor, that is monitoring the output of U7A (COMPARE1), initiates action to reduce the output of the dual DAC that controls LED intensity.

The microprocessor may reduce current through only one of the LEDs if necessary.

The SAT signal is then coupled through C55 to remove the DC offset or steady-state ambient energy artifact. The signal is then coupled to bandpass filter U13B to remove noise. The output of U13B is then introduced to a programmable gain circuit consisting of DAC U9 and operational amplifier U13A.

The signal is then coupled to full-gain amplifier U14B. The output of U14B is used by the modules's microprocessor as the sense point to determine input channel gain requirements. Positive peak detector U7B is employed to monitor the amplified SAT signal at the output of U14B. It produces a DC output (COMPARE2) proportional to the positive excursion of the amplified SAT signal pulses. If (COMPARE2) exceeds +10 V, the modules's microprocessor reduces U13A gain. The microprocessor may also reduce LED drive for one LED if necessary.

The SAT signal is finally coupled to the synchronous detector comprised of U10B, U14A, and associated resistors. When the positive input of U14A is grounded by U10B, the device is an inverting amplifier with a gain of one. When this input is not grounded, the device becomes a voltage follower with a gain of one. The output of the synchronous detector is applied to the filter/amplifier circuitry.

Filters / Amplifiers. The module includes two separate active filter channels: infrared and red. These low-pass filter / amplifier circuits and associated gating circuits recover the patient's pulse waveform from the multiplexed SAT signal. FET switches U15A and U15B are employed to separate the infrared information in the SAT signal from the red information. The gate control input signals (IRGATE/ and REDGATE/) are processor-controlled and operate in time sequence with the four-phase LED drive control. This switching action is used to control the inputs to the red and infrared filter / amplifier circuits.

The infrared filter / amplifier circuit is an active low-pass filter (total gain = 4) which responds to the patient's pulse modulation — reproducing the patient's pulse waveform at the filter / amplifier output. The infrared pulses (IR) are coupled to the first of two identical filter / amplifier stages (U22D and U22B), each having a gain of approximately two. The signal is then coupled to the last stage (U23B) which has a gain of one. The pulse waveform (IR) at the output of the filter / amplifier stages, must always be at a positive voltage level in order to be digitized by the analog-to-digital conversion circuitry. The final amplifier stage has an input offset of +25 mV to ensure that the waveform does not move to a negative level. The output (IR ADC) is then coupled to the analog-to-digital conversion section.

The red filter / amplifier circuit is an active low-pass filter (total gain = 8) which responds to the patient's pulse modulation — reproducing the patient's pulse waveform at the filter / amplifier output. The red pulses (RED) are coupled to the first of two identical filter / amplifier stages (U22A and U22C), each having a gain of approximately two. The signal is then coupled to the last stage (U23A) which also has a gain of two. The pulse waveform (RED) at the output of the filter / amplifier stages, must always be at a positive voltage level in order to be digitized by the analog-to-digital conversion circuitry. The final amplifier stage has an input of +25 mV to ensure that the waveform does not move to a negative level. The output (RED ADC) is then coupled to the analog-to-digital conversion section.

Analog-to-Digital Conversion Circuitry. The analog-to-digital (A/D) conversion block digitizes the infrared and red pulse waveforms . Sensor calibration information is also digitized for use in the saturation calculation algorithms. A/D converter U20 is a dual-channel device which produces a multiplexed serial output. Channel 1 (AIN1) accommodates either VCAL1 voltage or the analog pulse waveform (RED ADC) from the red filter / amplifier channel. Channel 2 (AIN2) accommodates either VCAL2 voltage or the analog pulse waveform (IR ADC) from the infrared filter / amplifier channel. These selections are determined by the configuration of quad FET switch U24. Switching is controlled by the signal RESISTORS. The output bit serial stream multiplexing of U20 is determined by logic signal ADCCHN, which determines the channel present on the ADCDATA line. The ADCDATA line is coupled directly to microprocessor U5 for saturation value and pulse rate calculation prior to being routed to the Model 118 display processing circuitry.

Communications. Four data signals are used to communicate between the Nellcor module and the SpO_2 Interface Board in the Model 118: CTS, RESET, RXD, and TXD.